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Biomass Gasification an Alternative Solution to Bagasse Waste Management

الكتلة الحيوية:الحل البديل لادارة مخلفات الباقاس

A project Submitted In Partial Fulfillment for the Requirements of the Degree of B.Eng. (Honor) In Mechanical Engineering

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صدق الله العظيم

Dedication

We gave more than a hand and a lot of hardship to them, and we suffered a lot of difficulties and today we are thankful for the sleepless night and the fatigue of the days and the conclusion of our journey between the depths of this humble work. To the beacon of science and Imam Mustafa to the illiterate who taught the educated to the master of creation to our noble Messenger Muhammad peace be upon him. To the fountain that does not tire of giving to those who have woven my happiness with woven threads from her heart to my dear mother. To those who sought and did well to enjoy the comfort and joy that did not spare anything to push me in the way of success, which taught me to rise the ladder of life with wisdom and patience to my dear father. To those who love them in my veins, and I will speak with their remembrance, and turn to my sisters and brothers. To whom we have traveled together, we are moving together towards success and creativity to those who join hands with us. To those who taught us letters of gold and words of derricks and phrases of the highest and most beautiful expressions in science to those who teach us letters and their thoughts lighthouse enlighten us the biography of science and success to our distinguished professors.

Acknowledgment

After cutting the long journey in the research, we came to the end of the day and thank all of the arrows in this success among them, **Dr. Abu Al-Noor** and the University of Sudan for Science and Technology, especially the workshop machines, and **Dr. Hamid** and the Department of **Civil Engineering and plumbing workshop** and all who stood with us until we reached this great achievement the **Kenna sugar company Eng. Hassan Mohamed Hassan**. The good illusion of those who drove us out of darkness to the light where the knowledge of knowledge.

Abstract

In the history of civilizations, the **21th** century can be described as a century of exponential growth in energy consumption and a rapid increase in population worldwide. As people know in the past period, Sudan has suffered from shortages or shortages of fossil fuels such as petroleum, natural gas and coal are the most important source of energy in the near future will become the supplier of this non-renewable fuel rate. So there is a need to find alternative fuels that are able to meet the world's energy demand. Biomass is the right choice because the fuel properties of the product are environmentally friendly. The result shows that a laboratory furnace can provide the process with a quantity of energy that can be stored or can be a feedstock for gasoline, alcohol, diesel and jet fuel.
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المستخلص:

في تاريخ الحضارات، يمكن وصف القرن الحادي والعشرين بأنه قرن من النمو الهائل في استهلاك الطاقة والزيادة السريعة في عدد السكان في جميع أنحاء العالم. وكما يعرف الناس في الفترة الماضية، عانت السودان من نقص أو نقص الوقود الأحفوري مثل البترول والغاز الطبيعي والفحم هي أهم مصدر للطاقة في المستقبل القريب سوف يصبح مورد هذه الوقود غير المتجدد معدل. لذلك هناك حاجة لإيجاد أنواع الوقود البديلة التي هي قادرة على تلبية الطلب على الطاقة في العالم. الكتلة الحيوية هو الخيار المناسب لأن خصائص الوقود المنتج صديقة للبيئة. وتبين النتيجة أن الفرن المختبري يمكن أن يوفر للعملية كمية من الطاقة يمكن تخزينها أو يمكن أن تكون مادة أولية للحصول على البنزين الكحول والديزل والوقود النفاث.

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Co	Carbon oxide.
No	Nitrogen oxide.
So	Sulphur oxide.
O2	Oxygen.
C	Carbon.
H2	Hydrogen.
Co2	Carbon dioxide.
HC	hydro Carbon.
CH4	Methane.
SB	sugarcane Bagasse.
TGA	Thermo gravimetric Anlayizer.
DTG	Derivative thermo Gravimeters.
IPCC	Intergovernmental panel on climate change.

CHAPTER ONE

INTRODUCTION

INTRODUCTION

1.1 Background:

The global energy demand has been steady increasing for the last several decades due to rapid industrialization and improvement of living standards of the society, globally. However, it has caused a long term and irreversible damage to the environment leading to global warming and climate change often discussed among the scientific community and policy makers at National and International platforms including Intergovernmental Panel on Climate Change (IPCC) since its establishment in 1988. The world community is more emphasizing on the clean and green energy for the sustainable development of the society and certain issues and possibilities are being discussed about switching to renewable energy (solar, biomass, wind etc.) for different but specific applications. Prior to the use of fossil fuel, the biomass was the main source of heating and cooking applications [1]. However, with the introduction of fossil fuels such as petroleum products, coal, natural gas, etc. the world becoming dependent on these fuels and nearly 80% of the total energy requirement is being met by these fuels causing/witnessing severe environmental problems, globally. Also, biomass is considered to be the prominent form of energy and having a significant share (10–14%) in the global energy load, while it has major share up to 90% of total energy supply in the remote and rural areas of the developing world. It is also likely to remain the main source of primary energy feedstock for the developing countries in the near future as around 90% of the world population is expected to reside in the developing countries by 2050 [2, 3]. Biomass stores chemical energy in the form of carbohydrates by combining solar energy and carbon dioxide using photosynthesis process. Biomass has been identified as the potential fuels since the carbon dioxide captured during photosynthesis releases while its combustion. It is available in different forms such as, agricultural and forestry residues, biological materials by-products, wood, organic parts of municipal and sludge wastes having variable moisture content and chemical elements. There are several routes to convert biomass into useful products depending on the biomass characteristics and the requirement of the end product and its applications. For woody biomass, the most common application is thermochemical conversion route viz. combustion for the production of heat energy while through gasification both heat and power generation requirements can also be met more effectively, efficiently and environment-friendly besides the biofuels production through pyrolysis for transportation and related applications. Among all the three main routes, gasification has been considered to be a more attractive process to exploit the energy from certain renewable and non-renewable biomass with better conversion efficiency for various end products such as heat, electricity, transportation fuels etc. [4]. Since gasification is the thermochemical conversion of solid biomass into combustible fuel in the presence of oxidant (lower than the stoichiometric combustion) carried out in a reactor called gasifier.

1.2 Problem statement:

Energy supply is the basic request of humankind for cooking heating manufacturing electricity generation and transportation. Most of the world relies on energy generation by combustion. The augmentation in combustion efficiency and pollutant reduction have become the main concerns of combustion researchers in academic societies and of industrial manufacturers .the renewable energy is one of methods to solve this problem .The aim of using biomass in combustion is to reduce the pollutant emission and decrease the rate of fossil fuel consumption.

1.2 Project objective:

The objective of this study lead to:

- To construction the test rig for gasification process.
- To study experimentally bagasse as fuel by using gasification process.

1.4 Significance of research

The energy is important for any human because without it cannot do any things and this study can help to solve world problem in this side.

1.5 Scope of Research:

This study in renewable energy include thermo dynamic, heat transfer, the flow of gas by gas dynamic and anlayize of flow in the process.

CHAPTER TWO

LITRATURE REVIEW

LITERATURE REVIEW

2.1 Introduction:

A conversion energy (also called a finite resource) is a resource that does not renew it self at a sufficient rate for sustainable economic extraction in meaningful human time-frames. An example is carbon-based, organically-derived fuel. The original organic material, with the aid of heat and pressure, becomes a fuel such as oil or gas[4] . Earth minerals and metal ores, fossil fuels (coal, petroleum, and natural gas) and groundwater in certain aquifers are all considered non-renewable resources, though individual elements are almost always conserved.

In contrast, resources such as timber (when harvested sustainably) and wind (used to power energy conversion systems) are considered renewable resources, largely because their localized replenishment can occur within time frames meaningful to humans.

The explosive increasing energy consumption is one of the critical challenges throughout the world, and currently significant percentage of the consumed energy comes from fossil fuels, such as petroleum, coal and natural gases. According to Song [4] the total energy consumption in the 20th century was about 10,048 million tons of oil equivalent, with 24% from coal, 39% from petroleum, 23% from natural gas, 6% from nuclear power, and only 8% from renewable energy, including hydroelectric power, biomass, geothermal, solar and wind energy[4].

2.2 Fossil fuel:

A fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing energy originating in ancient photosynthesis. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years. Fossil fuels contain high percentages of carbon and include petroleum, coal, and natural gas. Other commonly used derivatives include kerosene and propane. Fossil fuels range from volatile materials with low carbon to hydrogen ratios like methane, to liquids like petroleum, to nonvolatile materials composed of almost pure carbon, like anthracite coal. Methane can be found in hydrocarbon fields either alone, associated with oil, or in the form of methane catharses.

The theory that fossil fuels formed from the fossilized remains of dead plants by exposure to heat and pressure in the Earth's crust over millions of years was first introduced by Georgius Agricola in 1556 and later by Mikhail Lomonosov in the 18th century.

The Energy Information Administration estimates that in 2007 the primary sources of energy consisted of petroleum 36.0%, coal 27.4%, and natural gas 23.0%, amounting to an 86.4% share for fossil fuels in primary energy consumption in the world. [4]Non-fossil sources in 2006 included nuclear 8.5%, hydroelectric 6.3%, and others (geothermal, solar, tidal, wind, wood, waste) amounting to 0.9%. [5] World energy consumption was growing about 2.3% per year[5].

Although fossil fuels are continually being formed via natural processes, they are generally considered to be non-renewable resources because they take millions of years to form and the known viable reserves are being depleted much faster than new ones are being made.

The use of fossil fuels raises serious environmental concerns. The burning of fossil fuels produces around 21.3 billion tones (21.3 gigatonnes) of carbon dioxide (CO_2) per year. It is estimated that natural processes can only absorb about half of that amount, so there is a net increase of 10.65 billion tons of atmospheric carbon dioxide per year.[6] Carbon dioxide is a greenhouse gas that increases radiative forcing and contributes to global warming. A global movement towards the generation of renewable energy is underway to help reduce global greenhouse gas emissions.Since oil fields are located only at certain places on earth. Only a select group of countries are oil-independent; the other countries depend on the oil-production capacities of these countries Petroleum and natural gas are formed by the anaerobic decomposition of remains of organisms including phytoplankton and zooplankton that settled to the sea (or lake) bottom in large quantities under anoxic conditions, millions of years ago. Over geological time, this organic matter, mixed with mud, got buried under heavy layers of sediment. The resulting high levels of heat and pressure caused the organic matter to chemically alter, first into a waxy material known as kerogen which is found in oil shale, and then with more heat into liquid and gaseous hydrocarbons in a process known as cat agenesis. Despite these heat driven transformations (which may increase the energy density compared to typical organic matter), the embedded energy is still photosynthetic in origin.

There is a wide range of organic, or hydrocarbon, compounds in any given fuel mixture. The specific mixture of hydrocarbons gives a fuel its characteristic properties, such as boiling point, melting point, density, viscosity, etc. Some fuels like natural gas, for instance, contain only very low boiling, gaseous components. Others such as gasoline or diesel contain much higher boiling components. Terrestrial plants, on the other hand, tend to form coal and methane. Many of the coal fields date to the Carboniferous period of Earth's history. Terrestrial plants also form type III kerogen, a source of natural gas[5].

2.2.1 Importance:

Fossil fuels are of great importance because they can be burned (oxidized to carbon dioxide and water), producing significant amounts of energy per unit mass. The use of coal as a fuel predates recorded history. Coal was used to run furnaces for the melting of metal ore. Semi-solid hydrocarbons from seeps were also burned in ancient times but these materials were mostly used for waterproofing and embalming.

Commercial exploitation of petroleum, largely as a replacement for oils from animal sources (notably whale oil), for use in oil lamps began in the 19th century Natural gas, once flared-off as an unneeded byproduct of petroleum production, is now considered a very valuable resource. Natural gas deposits are also the main source of the element helium.

Heavy crude oil, which is much more viscous than conventional crude oil, and tar sands, where bitumen is found mixed with sand and clay, are becoming more important as sources of fossil fuel.[7] Oil shale and similar materials are sedimentary rocks containing kerogen, a complex mixture of high-molecular weight organic compounds, which yield synthetic crude oil when heated (prolyized). These materials have yet to be exploited commercially. [6] These fuels can be employed in internal combustion engines, fossil fuel power stations and other uses.

Prior to the latter half of the 18th century, windmills and watermills provided the energy needed for industry such as milling flour, sawing wood or pumping water, and burning wood or peat provided domestic heat. The wide scale use of fossil fuels, coal at first and petroleum later, to fire steam engines enabled the Industrial Revolution. At the same time, gas lights using natural gas or coal gas were coming into wide use. The invention of the internal combustion engine and its use in automobiles and trucks greatly increased the demand for gasoline and diesel oil, both made from fossil fuels. Other forms of transportation, railways and aircraft, also required fossil fuels. The other major use for fossil fuels is in generating electricity and as feedstock for the petrochemical industry. Tar, a leftover of petroleum extraction, is used in construction of roads. [8]

2.2.2 Environmental effects:

Global fossil carbon emission by fuel type, 1800–2007. Note: Carbon only represents 27% of the mass of CO2 Main article: Environmental impact of the energy industry The United States holds less than 5% of the world's population, but due to large houses and private cars, uses more than a quarter of the world's supply of fossil fuels.[9] In the United States, more than 90% of greenhouse gas emissions come from the combustion of fossil fuels.[9][not in citation given] Combustion of fossil fuels also produces other air pollutants, such as nitrogen oxides, sulfur dioxide, volatile organic compounds and heavy metals.

2.3 Renewable energy:

Renewable energy refers to energy that occurs naturally and repeatedly in the environment. This can be energy from waves, wind, the sun and geothermal heat from the ground. Renewable energy can also be produced from plant sources, such as wood or crops. Organic fuel sources can also be found in by-products from manufacturing and other processes. Under certain circumstances, these can be converted to renewable energy using environmentally acceptable processes. As the term suggests, renewable energy will not run out, unlike energy from fossil fuels. [10]

As well as reducing carbon emissions, using renewable energy sources can make financial sense for organizations. Renewable energy sources can be available on site (such as wind and solar energy) or produced locally (such as biomass). Because it is produced under local control, the use of renewable energy ensures increased security of supply and can result in greater energy price Stability for businesses, making it easier to predict future energy costs. For these reasons, renewable energy is becoming more attractive from economic and strategic viewpoints. Renewable energy can offer significant environmental and economic benefits [10]. However, it should be stressed that it is one of the last steps in the energy hierarchy – the order in which energy saving and 'green' energy measures should be prioritized. The energy hierarchy states that organizations and individuals should pursue energy issues in the following order:

- Reduce the need for energy.
- Use energy more efficiently.
- Use renewable energy.
- Any continuing use of fossil fuels should be clean and efficient.

There are many type of renewable energy:

2.3.1Geothermal energy:-

Energy that comes from the ground; power extracted from heat stored in the earth (*Geo:* earth………*Thermal:* heat).

Figure (2.1): Geothermal system

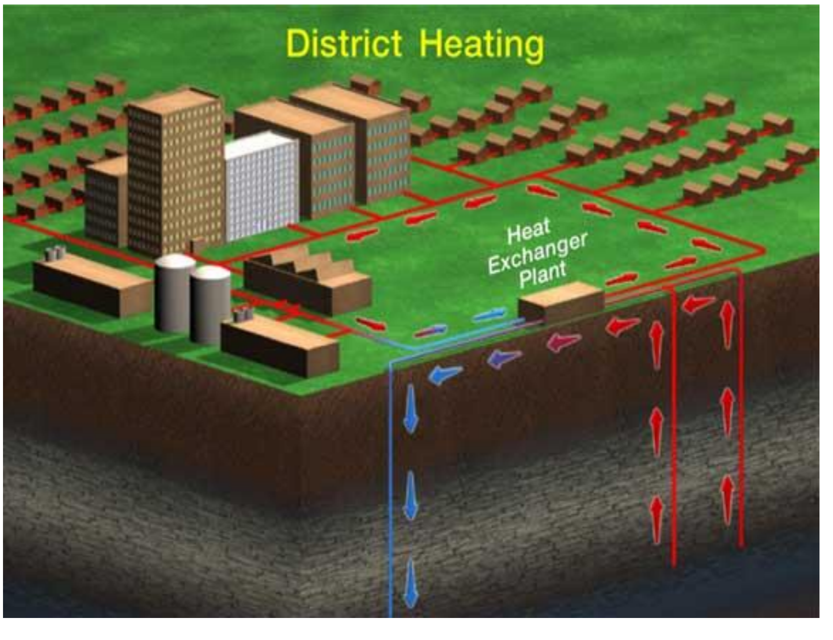


Figure (2.2)

Building use geothermal energy

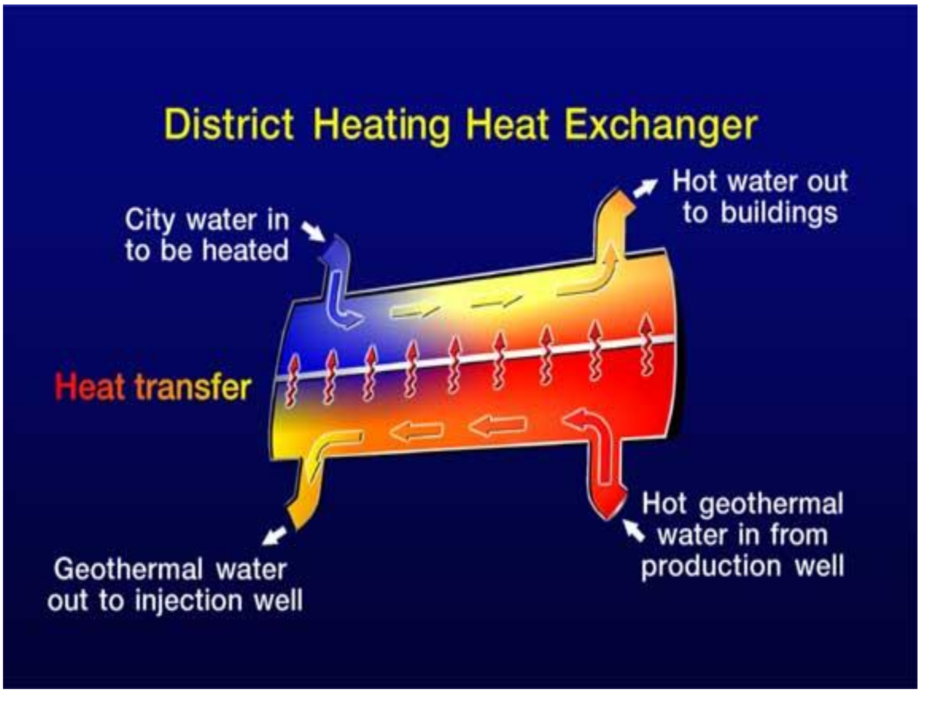


Figure (2.3)

The work of heat exchanger in geothermal system

2.3.2 Solar energy:

Solar energy is radiant energy that produced by the sun. Every day the sun radiates a huge amount of energy. One hour delivers enough energy to power the world economy for one year. [10]

The son is a big ball of gases mostly hydrogen and helium atoms. The hydrogen atoms in the son's core combine to form helium and generate energy in a process called nuclear fusion. Sudan has a high rate of solar radiation. This amount of radiation can be use. This highest amount is found in north of Sudan and decrease gradually to the south as shown on figure below:

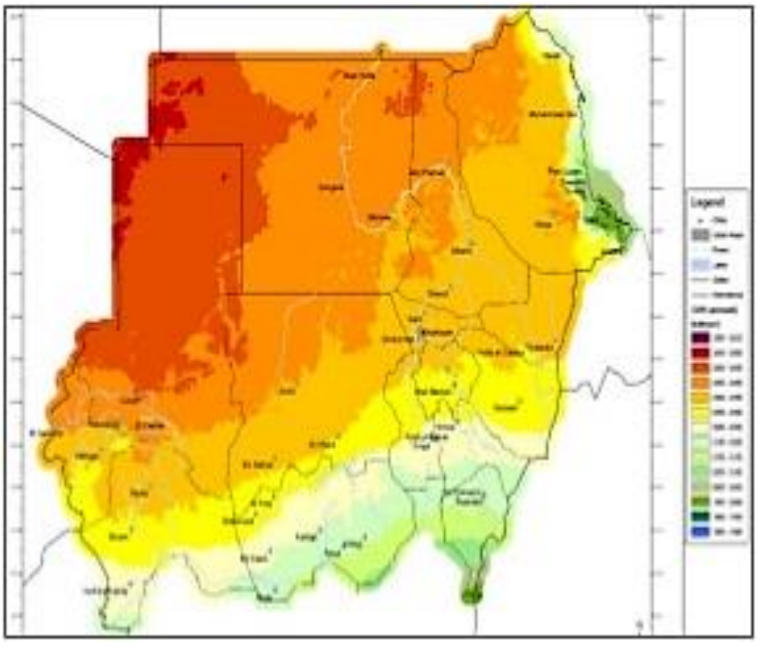


Figure (2.4) solar energy in Sudan

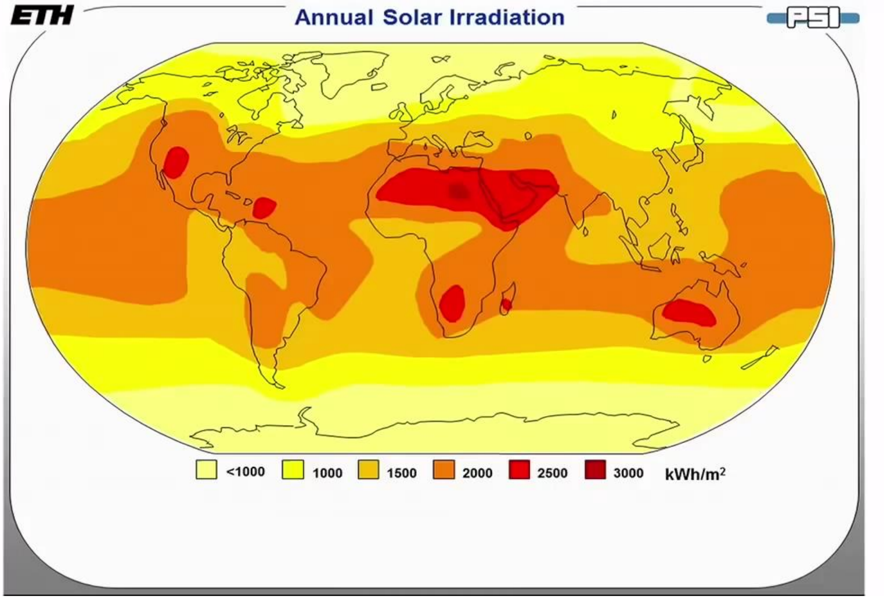


Fig (2.5) solar energy in the world

2.3.3Hydrogen energy:

The solar syngas is a natural hydrocarbon fuel comes from water, carbon dioxide and solar energy.[10]

Solar-driven thermochemical cycles based on metal oxide redox reactions can split H2O and CO2 to produce H2 and CO (syngas). And this reactions happen in tow step:

Reduction step - Oxidation step.

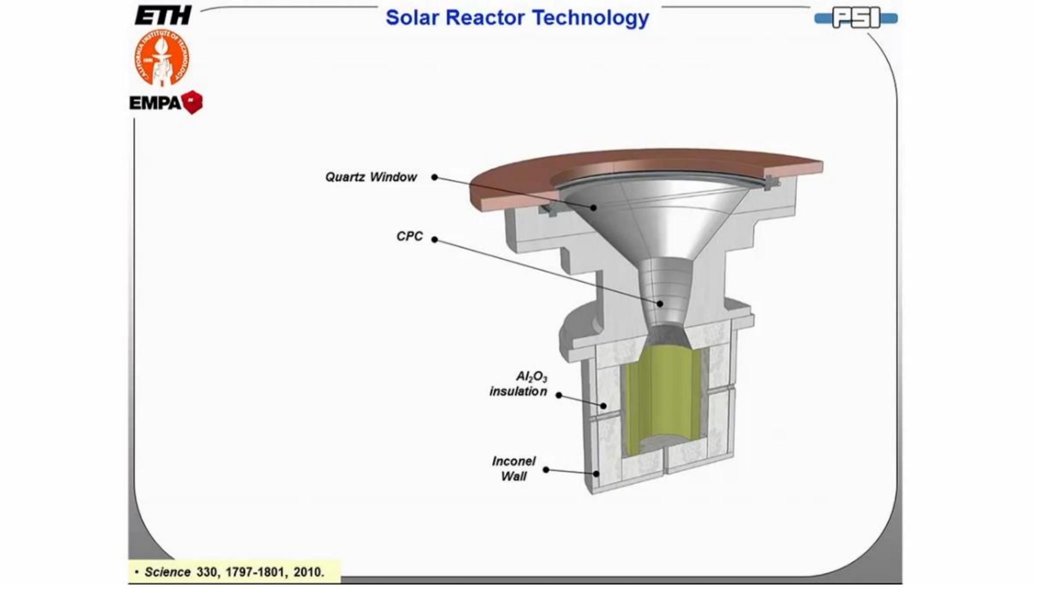


Figure (2.6) Hydrogen reactor

Another way to produce hydrocarbon fuel:

1\Photo-catalytic:

*Using TiO2 catalytic:

The image above displays the path of UV light activating the TiO2 surface. [10] Water and carbon dioxide react at the surface of the photo-catalyst producing hydrocarbons like methane (CH4).

$TiO_2 + h\upsilon \rightarrow e^-_{cb} + h^+_{vb}$ (1)

$CO_2 + 2H^+ + 2e^- \rightarrow CO + 2H_2O$ (2)

$CO_2 + 8H^+ + 8e^- \rightarrow CH_4 + 2H_2O$ (3)

$2H^+ + 2\,e^- \rightarrow H_2$ (4)

$H_2O+2h^+ \rightarrow 1/2\ O_2 + 2H^+$ (5)

2.3.4 Wind Power:

The first use of wind power was to sail ships in the Nile some 5000 year ago. The Europeans used it to grind grains and pump water in the 1700s and 1800s. The first windmill to generate electricity in the rural U.S.A. was installed in 1890. Today, large wind-power plants are competing with electric utilities in supplying economical clean power in many parts of the world[10, 11]. The average turbine size of the wind installations has been 300 kW until the recent past. The newer machines of 500 to 1,000 kW capacity have been developed and are being installed. Prototypes of a few MW wind turbines are under test operations in several countries, including the U.S.A:

Is a conceptual layout of modern multi megawatt wind tower suitable for utility scale applications?

Improved turbine designs and plant utilization have contributed to a decline in large-scale wind energy generation costs from 35 cents per kWh in 1980 to less than 5 cents per kWh in 1997 in favorable locations At this price, wind energy has become one of the least-cost power sources. Major factors that have accelerated.[10]

2.3.4.1 The wind-power technology developments are as follows:

High-strength fiber composites for constructing large low-cost blades. Falling prices of the power electronics. Variable-speed operation of electrical generators to capture maximum energy improved plant operation, pushing the availability up to 95 percent economy of scale, as the turbines and plants are getting larger in size accumulated field experience (the learning curve effect) improving the capacity factor.

The wind energy stands out to be one of the most promising new sources of electrical power in the near term. Many countries promote the wind-power. [10]

2.3.5 Biomass Energy:

Biomass energy is the use of organic materials such as wood, straw and dedicated energy crops, for the generation of heat, electricity or motive power. It can be viewed as a form of solar energy – the sun's energy is captured and stored in growing material via the process of photosynthesis. This energy is released through combustion (burning) and can be used to generate heat (and electricity where the biomass boiler is connected to a combined heat and power unit). The majority of industrial and commercial applications use boiler plant to recover the heat from combustion. Biomass boilers are available to produce either hot water or steam. Where appropriate, steam can be further used in a turbine to generate power. Heat can also be recovered from the steam turbine system in a combined heat and power unit. Sustainably produced biomass is considered a low carbon fuel source because the CO2 released when it is burned was first absorbed by the plant during its growth. With sustainable forest and crop management this will be recaptured by new growth, giving no net emission. However, the other energy inputs necessary to its production may affect the carbon balance, for example, energy used in a drying process or that used by vehicles harvesting or transporting the biomass to its point of use. Converting certain types of land to biomass production can also lead to net increases in carbon emissions, due to changes in the carbon stock of the land or displacement of agricultural production elsewhere be considered sustainable Biomass fuels, unlike other renewable sources, have to be sourced and purchased unless they are obtained as a by-product or waste material from a process used in the business. Prices vary depending on the material type and delivery distance. As a result, it is essential to ensure that a local and secure supply of biomass feedstock is available.

2.3.5.1 Types of biomass:

A . Agricultural crop residues:

Rice, maize, wheat, coconut, groundnut, bean, vegetables, jute and sugarcane etc. are the main agricultural crops in Bangladesh. Agricultural crops produce residues that can be used to generate energy. Crop residues are collected either at the same time or after harvesting of the primary crops. Depending on the period of residues collection, there are two types of crop residues. One is field residue and other is processing residue. Field residues are generally used as fertilizer and collected from the field after harvesting. Process residues are collected from the mills, where the crops are further processed. Rice straw, rice husk, bagasse from sugarcane and jute stick cover about 46% of the total biomass energy[12]. Crop residues are used not only for renewable energy source, but also for cooking and raw manufacturing material areas. Therefore, village people use agricultural crop residues (straw, husk, etc.) as the major source of cooking fuel followed by dry cow dung, leaves and twigs, woods and kitchen by product, etc [13].

B. Animal manure:

Animal manure is a mixture of organic material, moisture and ash. The mature can be decomposed both in aerobic and anaerobic conditions. Under aerobic condition, carbon dioxide and stabilized organic materials are formed. On the other hand, at anaerobic condition, methane, carbon dioxide gas and stabilized organic materials are created[14]. Cattle, goats, buffaloes and sheep are the general sources of animal manure in the country. Animal manure is often used as fertilizer. [15]

C. Municipal solid waste:

Municipal solid waste (MSW) is the heterogeneous composition of Wastes that is organic and inorganic, rapidly and slowly biodegradable, Fresh, hazardous and non-hazardous, generated from various sources in urban areas due to human activities [16].

2.3.6 The process of producing syngas:

2.3.6.1 Pyrolysis:

Pyrolysis is a decomposition process of biomass at suitable operating temperature in the absence of oxygen. [17]

Conventional slow, fast and flash are the three processes of pyrolysis. Slow pyrolysis is used for the production of charcoal under slow heating rate of 0.01–1 Kelvin per second (K/S) and temperature of 273.85–626.85 C. Fast pyrolysis is associated with the rapidly heated biomass at high temperature (576.85–976.85 1C) and heating rate (10–200K/S). The operating temperature and heating rate for flash pyrolysis are about 776.85–1026.85 C and above 1000 K/S respectively.

The flash pyrolysis is generally used to convert small biomass particles into liquid fuel (bio-oil or bio-crude**. [15]**

2.3.6.2 Fermentation:

Fermentation is used commercially on a large scale in various countries to produce ethanol from sugar crops (e.g. sugar cane, sugar beet) and starch crops (e.g. maize, wheat). The biomass is ground down and the starch is converted to sugar by enzymes. After that, sugar is converted to ethanol using yeast and ethanol is purified by distillation. The solid residue from the fermentation process can be used as cattle feed. In the case of sugar cane, the bagasse can be used as fuel for boilers or subsequent gasification. [18]

2.3.6.3 Gasification:

The gasification process was discovered in France and England independently in 1798 but the technology development was come into the implementations after 60 years when it could be possible to light much of London using manufacturing gas produced from the coal. First gasification process was used in the blast furnace over 180 years ago in France to produce the combustible fuels from organic feeds to drive the first vehicle designed by J. W. Parker in Scotland in 1901. By 1920, most of the American towns and cities were connected with town gas supplied for cooking and lighting applications. The importance of town gas supply was realized and sooner the crisscross of the first natural gas pipeline was drawn in 1930 to transport the natural gas from oil fields of Texas to Denver. Until 1970, England continued using the town gas but the plants were dismantled following the discovery of North Sea oil which led to the new era of liquid fuels[19]. The French government contributed significantly to the development of gasification system and emphasized on its usage for automobile and electricity generation. The possibility of energy production from these combustible gases was soon realized by emerging it in Europe producer gas systems and these systems were run by using charcoal and peat as the feed materials [20].

Gasification is a well-known thermochemical process that converts a solid fuel (usually biomass or coal) into a combustible gaseous product (syngas) through partial oxidation, using a gasifying agent in sub stoichiometric conditions [21, 22]. When air is used as gasifying agent the syngas consists mainly of carbon monoxide (CO), hydrogen (H2), carbon dioxide (CO2), steam (H2O), methane (CH4) and nitrogen (N2) with proportions that depend on air/biomass ratio and MC. In addition there are trace amounts of higher hydrocarbons (such as acetylene, ethane), and various contaminants such as small char particles, fly ash and tar [23] [24]. It is well known that the entire gasification process can be divided into four successive stages: drying, pyrolysis, combustion and gasification

Also we define it by another way is the conversion of biomass into a combustible gas mixture by the partial oxidation of biomass at high temperatures. The range of temperature is about 800–900 1C. The produced gas of low calorific value (about 4–6 MJ/N m3) can be burnt directly or used as a fuel for gas engines and gas turbines

[25, 26]

2.4 Gasification

Gasification is a thermal treatment technology which involves the conversion of organic material into combustible gases by partial oxidation under the application of heat. Typical feed stocks include carbon rich materials such as bio-solids,[26] solid waste, agricultural wastes and mixed organic waste (food waste, garden waste, paper pulp).Typical products are the combustible gas and char. Gasification is considered an energy efficient technology for reducing the volume of solid waste and for recovering energy with a heating value 10-15 per cent that of natural gas.

Gasification with pyrolysis of solid waste requires pre-treatment to ensure contaminants are removed. Feedstock is then loaded into the reactor and temperatures of approximately 1000°C are applied. The type of reactor used varies with the technology provider and may be a fixed bed, fluidized bed or moving bed type, or a rotary kiln. The majority of carbon is converted to a gaseous form, leaving an inert residue from the breakdown of organic molecules. A combustible gas (synthesis gas or syngas) is produced which is composed of mainly carbon monoxide, hydrogen and methane. This can be used as a fuel in boilers, internal combustion engines or gas turbines, or as a raw material resource for producing methanol or hydrogen. This technology is widely seen as an energy efficient technique for reducing the volume of organic waste material and for recovering energy,[26] with the potential for generating useable energy of 500-600 kWh/tone of waste. Emissions are significantly less than from conventional incinerators.

The advantages of Gasification:

- Gasification reduces solid waste volume by 85 to 92[26] per cent
- Gasification is economically viable at a small scale and tends to emit lower amounts of Sox, NOx and dioxins than combustion.
- Feedstock flexibility.
- Product flexibility.
- High efficiency.

- High public acceptance.

Disadvantages of Gasification:

- Gasification process adds greenhouse gases to the atmosphere.

- The ash which remains after gasification, 8 to 15 per cent of the original volume, is toxic and presents special problems because of the acidic or low pH conditions in landfills.

- Leaching of toxic metals cadmium, lead, and mercury occurs more rapidly at low pH, resulting in contamination of groundwater.

2.4.1 Principal and fundamental of gasification:

Gasification is one of the popular processes that produces energy in the form of synthesis gas and, at the same time, reduces the environmental hazards of the raw feedstock. Gasification is a continuous sub-stoichiometric (oxygen (O2) starved) burning process which burns solid feed stocks (for example, solid waste) in a reactor generating a syngas and pyrolysis liquids (tars) as fuels. It takes place in the presence of a limited amount of oxidizer (air, O2 or steam). Gasification can be broadly defined as the thermo-chemical conversion of a solid or liquid carbon-based material (feedstock) into a combustible gaseous product (combustible gas) by the supply of a gasification agent (another gaseous compound). The thermo-chemical conversion changes the chemical structure of the biomass by means of high temperature. The gasification agent allows the feedstock to be quickly converted into gas by means of 52 different heterogeneous reactions[27].

The gasification process is comprised of three linked processes: pyrolysis (decomposition), gasification, and partial combustion. Partial combustion is necessary because it supplies the heat required by the endothermic gasification reactions [27].Different types of biomass resources are used as gasification feedstock.

Biomass resources include wood from plantation forests, residues from agricultural or forest production, and organic waste by-products from industry, domesticated animals and human activities such as solid waste

[27].Energy can be recovered from solid waste through various technologies, such as:

Combustion, a rapid chemical reaction of two or more substances, which is commonly called burning. In practical combustion systems, the chemical reactions of the major chemical species, carbon (C) and hydrogen (H2) in the fuel and oxygen (O2) in the air, are fast at the prevailing high temperatures (approximately, greater than 900°C) because the reaction rates increase exponentially with temperature.

Gasification, where the fuel is heated with little or no O2 to produce 'syngas' which can be used to generate energy or as a feedstock for producing methane (CH4), chemicals, biofuels or H2.

Solid waste gasification processes involve a number of steps, namely feedstock preparation, drying, gasification, and gas cleaning and burning.

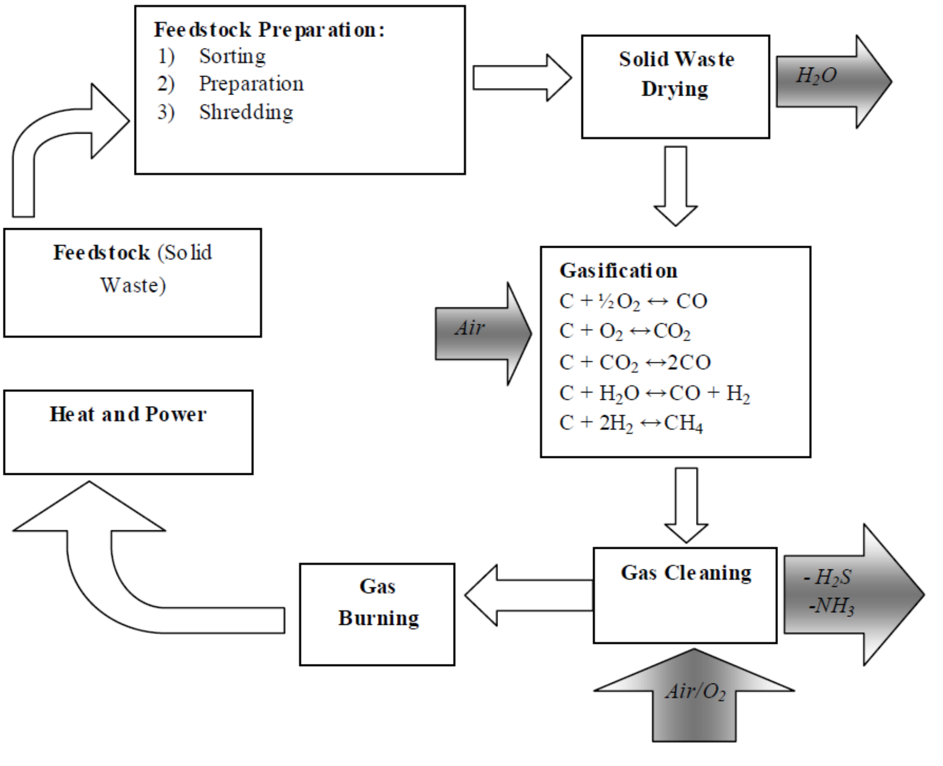


Figure **(2.7) Schematic diagram of solid waste gasification processes.**

$C + O_2 = CO_2$ (carbon combustion) (1)

$C + 0.5O_2 = CO$ (carbon combustion) (2)

$C + CO_2 = 2CO$ (Boudouard) (3)

$C + H_2O = CO + H_2$ (water-gas) (4)

$CO + H_2O = CO_2 + H_2$ (CO shift) (5)

$C + 2H_2 = CH_4$ (methanation) (6)

$H_2 + 0.5O_2 = H_2O$ (H_2 combustion) (7)

$CH_4 + H_2O = CO + 3H_2$ (8)

Gasification can be classified in several ways:

- By gasification agent: Air-blown gasifiers, oxygen gasifiers and steam gasifiers.
- By heat source: Auto-thermal or direct gasifiers (heat is provided by partial combustion of biomass) and auto-thermal or indirect gasifiers (heat is supplied by an external source via a heat exchanger or an indirect process).
- By gasifier pressure: Atmospheric or pressurized.
- by reactor design:
    - Fixed-bed (updraft, downdraft, cross-draft and open-core).
    - Fluidized-bed (bubbling, circulating and twin-bed).
    - Entrained-flow: These gasifiers are commonly used for coal because they can be slurry-fed in direct gasification mode, which makes solid fuel feeding at high pressures inexpensive. These gasifiers are characterized by short residence time, high temperatures, high pressures and large capacities.
    - Stage gasification with physical separation of pyrolysis, oxidation and/or reduction zones.

2.5Types of gasifier:

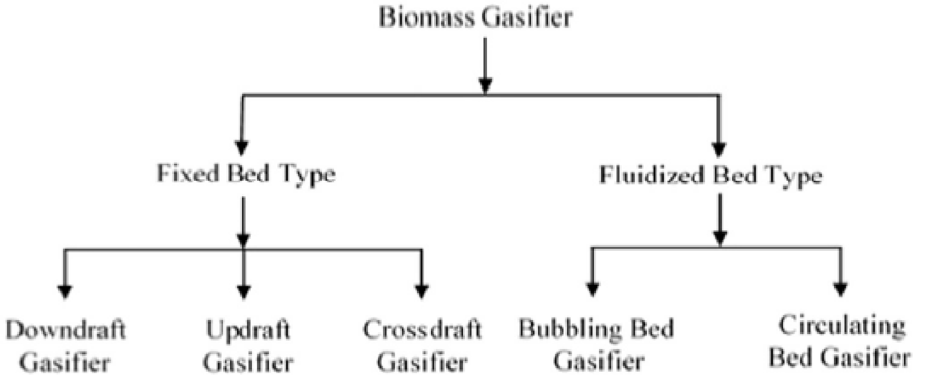


Fig (2.8) Classification of biomass gasifier [28]

The design of a biomass gasifier depends on the fuel availability, shape and size, moisture content, ash content and end user applications. Different types of biomass gasifiers are available in various size and design depending on the requirements and basically, classified as fixed and fluidized bed type gasifiers[28]. As gasification systems involve an interaction of air/oxygen/steam and biomass in the fixed bed type gasifier hence, they can be classified according to the way of interaction of either air/oxygen or steam with biomass such as (downdraft gasifier, Updraft gasifier, cross draft gasifier).

2.5.1 Fixed bed type gasifier

Fixed bed or moving bed type gasifier are having a bed of solid fuel particles through which gasifying agents (i.e. air, oxygen, and steam) and gas pass either up or down. 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 designed to operate at moderate pressure conditions of 25–30 atm. The gas cooling and cleaning system associated with fixed bed gasifier are normally consists of wet scrubbing, cyclone and dry filtration. During the gasification process, the fixed bed gasifiers move slowly down the reactor. These gasifiers are simple in construction, made of concrete or steel and generally operate at low gas velocity, high carbon conversion and long solid residence time. They are highly affected by the formation of tar contents, however, recent progress in tar control methods has given credible options. These gasifier has been reported suitable for small-scale heat and power generation applications [19, 29, 30]. The fixed bed type gasifiers are further classified as down- draft, updraft and cross draft gasifiers and discussed in detail as below [19, 30] [29]

2.5.1.1 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. All the decomposition products from both pyrolysis as well as drying zones are forced to pass through the oxidation zone for thermal cracking of volatile materials and produce less tar content and hence, the better quality fuel gas. Here, air interacts with the pyrolyzation of biomass before it contacts the char and accelerates the flame which maintains the process of pyrolysis. At the end of pyrolysis zone, the gases obtained in the absence of oxygen are CO2, H 2O, CO, and H2, called flaming pyrolysis. In flaming pyrolysis, the gases obtained during downdraft gasification are due to consumption of 99% of the tar in the process itself leading to low particulate and tar content in the gas and hence, suited for small scale power generation applications [23, 28].

2.5.1.2 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 and hence, these gasifiers are also called counter-current gasifier. In addition to the pyrolysis products and drying zone steam, the gas produced in the reduction zone with high calorific value leaves the reactor. In some updraft gasifiers, steam is evaporated into the combustion zone to obtain quality fuel gas and prevents the gasifier from overheating as well. This type of gasifier has the highest thermal efficiency as the hot gas passes through the fuel bed and leaves the gasifier unit at low temperature whereas some part of the sensible heat of producer gases is also used within the system for biomass drying and steam generation[31]. 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. However, some bottlenecks such as, great sensitivity to tar and moisture content of the fuel, low production of syngas, long start up time of the engine, and poor reaction capability are also associated with these systems [28].

2.5.1.3 Cross draft gasifier:

Although cross draft gasifiers have certain advantages over updraft and downdraft gasifier but they are not of ideal type. Cross draft gasifier is one of the simplest types of gasifier in which the fuel enters from the top and the thermochemical reactions occur progressively as the fuel descends in the reactor. Here, the air will enter into the reactor from the sides, rather than from the top or the bottom as shown in Fig. 3(c). Unlike upward and downdraft gasifier, cross draft gasifier has separate ash bin, fire and reduction zone and hence, limit the fuel used for operation with less ash content in the producer gas[32]. The main advantages of cross draft gasifiers are the 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. These gasifiers are having very few applications due to its only advantage of the presence of good permeability of the bed and hence, not much work has been reported in the literature so far.

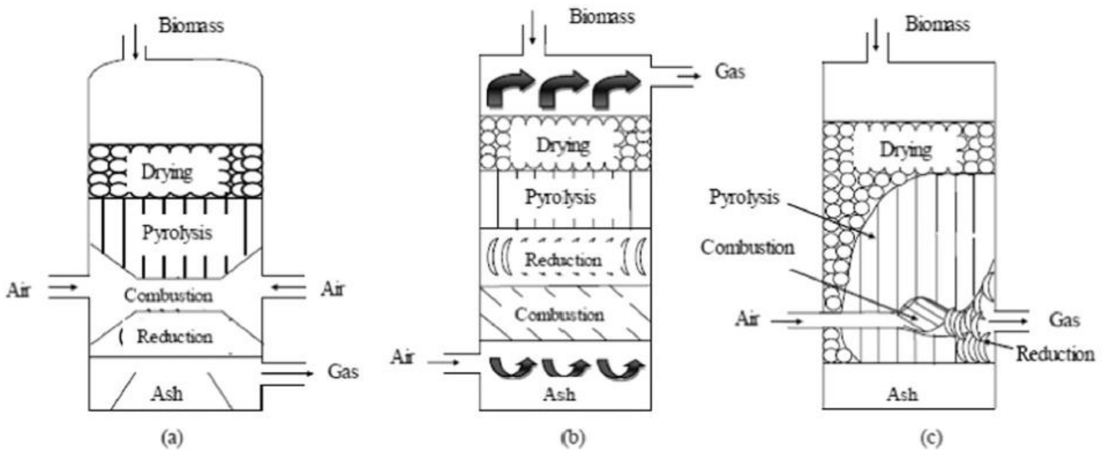


Figure (2.9) Schematic view of (a) Downdraft (b) Updraft and (c) Cross draft gasifier[15].

2.5.2 Fluidized bed type gasifier:

Foundation of this type of gasifier is based on the principle of fluidization in which both the fuel and inert bed material behaves like a fluid. Such behavior is observed when the fluidization medium like air, steam, oxygen, and their mixture is allowed to force through the solid inventory of the reactor [33, 34]. These gasifiers employ back mixing which leads to the efficient mixing of the feedstock particles with the particles already undergoing gasification. Silica has been considered as the most commonly used inert bed material for these types of gasifiers, however, other bulk solids such as, sand, olivine, glass beads, dolomite etc. exhibits catalytic features are also in recent trends to minimize the tar problems. These gasifiers are differing from the fixed bed gasifier in the sense of design configurations and ash conditions such as, dry or agglomerated etc. for improving the use of the char formed during the process. 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. Operating temperature of a fluidized bed reactor depends on the melting point of bed material and generally varies from 800 to 900 °C which is relatively low and hence, gasification reactions do not reach at chemical equilibrium at such low temperature conditions unless any catalyst is used. Short gas residence time is also another cause of not achieving a chemical equilibrium. Due to these factors, hydrocarbon contents in producer gas in case of the fluidized bed reactor fall in the range of the fixed bed gasifier. However, the carbon conversion efficiency of these gasifiers is comparatively high and reported to be up to 95%. These gasifiers are very suitable for scaling up due to their design and excellent mixing properties and hence, they are also capable of handling a wider range of fuel particle size[35]. The fluidized bed gasifiers are also having provision for the use of additives to accelerate the phenomenon of tar conversion. However, biomass materials having high contents of ash and alkali metals, such as grasses, canes, almond hull, rice and wheat straws, can also form eutectics with the presence of silica either in the bed materials or in the fuel ash itself. This will lead to the stickiness of the particles and eventually forms bigger lumps which ultimately cause defluidization and necessary shut down of the reactor is frequently required for cleaning periodically [31]. The development of suitable corrective measures is needed to fix such problems. For instance, the addition of a fluidized bed may increase the melting point of eutectics and thus allow gasification at high temperature conditions for larger periods of time. However, this process is not significantly effective unless the concentration of limestone in the fluidized bed is maintained for extended periods of time. Moreover, the addition of calcined limestone may allow gasification at a higher temperature (above 900 °C) over periods of time to minimize the risk of agglomeration and prevent from the regular replacement of bed. Due to char sticking and tarring, uncertainties in the collection and measurement of carbon removed by cyclone and thimble filters have been estimated to be ±4% and ±20%, respectively [15]. The fluidized bed gasifiers are having many characteristics such as, load and fuel flexibility, high heat transfer rates, moderate requirements of gasification medium, uniformity of high temperature through the gasifier and high cold gas efficiency. As stated above, however, these gasifiers are also affected by tar and dust particles produced due various biomass feedstock's (grasses, canes, almond hull, rice and wheat straws), which not only reduced the quality of fuel gas but also leads to the malfunctioning of some equipment’s including the prime mover, in long run [36, 37]. Also, depending upon the degree of fluidization and bed height, fluidization bed reactors have been categories in two types namely, bubbling and circulating fluidized bed reactor discussed in detail as below [31].

R2.5.2.1 Bubbling bed gasifier:

Bubbling bed gasifiers are very simple in construction and operation in which the gasification of different kinds of feedstock takes place under high pressure fluidized medium such as, air, oxygen and steam is allow to pass through the reactor bed having inert bed materials such as sand, dolomite etc. as shown in Fig. 4(a). Generally, these gasifiers are designed to operate at a very low gas velocity typically below 1 m/s. The solid particles while moving along the gas flow are separated from the gas in cyclone and get collected in the bottom of the fluidized bed reactor. Most of the part of conversion process takes place within the bubbling bed region and further extent lesser for tar conversion. They are capable of operating at the high average temperature of 850 °C and hence, more thermal decomposition of feedstock can be reported. However, the carbon conversion efficiency of bubbling bed gasifier is observed to be lower than those of the circulating fluidized bed gasifier due to stickiness behavior of feed particle which leads to the reduction of contact area between the particles[38]

2.5.2.2 Circulating bed gasifier:

In circulating bed gasifier, the solids entrained with the high fluidizing gas velocity are recycled back to the bed reactor. (b) to improve the carbon conversion efficiency which was observed to be very low in the case of bubbling bed gasifier. These gasifiers are designed to operate at a higher gas velocity ranging from 3 to 10 m/s. As compared to the bubbling fluidized bed reactor, the energy throughput per unit of reactor cross-sectional area has been reported higher for circulating fluidized bed gasifier. Besides the improving carbon conversion efficiency, these types of gasifier are also suffering from high tar and dust related problems as well. But both are designed to operate under pressurized conditions for further increase in the yield of final product. The main applications of the circulating bed gasifier are in boiler, paper industry, cement kiln and power generation etc. Since the process of gasification is comprised of several complex physiochemical reactions which are very difficult to monitor externally and hence, has been the keen interest of researchers from the beginning of this area of research. In gasification, the biological chemical reactions are having many inherent properties which highly affect the process effectiveness and subsequently the end user applications. Depending upon the operating parameters, gasification process takes place in many phases such as, biomass drying, pyrolysis, oxidation and reduction and each process should be carried out under optimum conditions to obtain the desired quality of the end product.

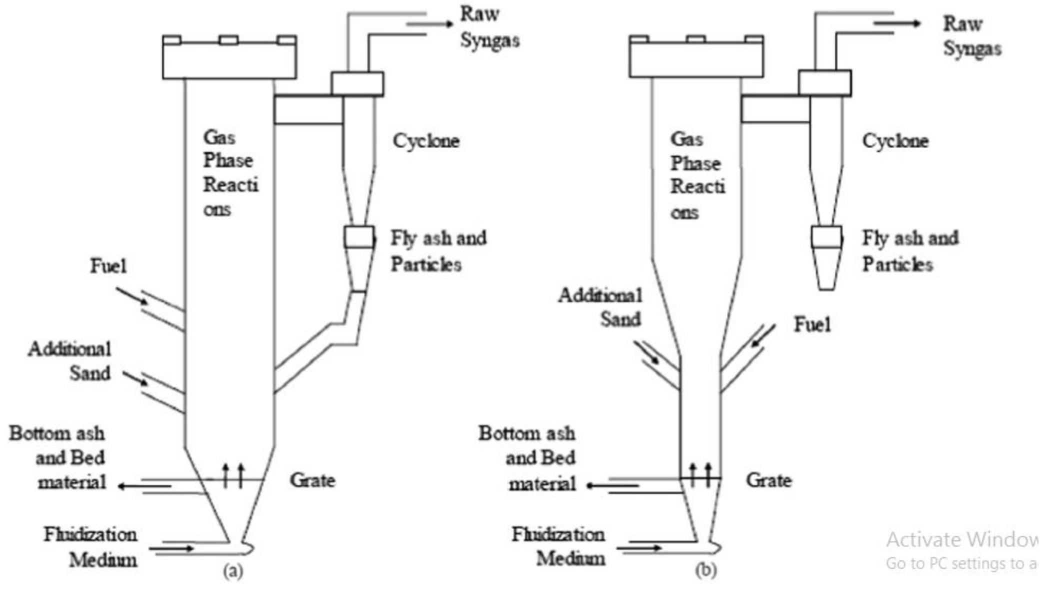


Fig (2.10) Schematic view of (a) Bubbling and (b) Circulating bed type gasifier.

2.6 Sugarcane:

Sugarcane or sugar cane, are several species of tall perennial true grasses of the genus *Saccharum*, tribe Andropogoneae, native to the warm temperate to tropical regions of South Asia and Melanesia ,and used for sugar production. It has stout, jointed, fibrous stalks that are rich in the sugar sucrose, which accumulates in the stalk internodes. The plant is two to six meters (six to twenty feet) tall. All sugar cane species interbreed and the major commercial cultivars are complex hybrids. Sugarcane belongs to the grass family Poaceae, an economically important seed plant family that includes maize, wheat, rice, and sorghum, and many forage crops.

Sucrose, extracted and purified in specialized mill factories, is used as raw material in the food industry or is fermented to produce ethanol. Ethanol is produced on a large scale by the Brazilian sugarcane industry. Sugarcane is the world's largest crop by production quantity In 2012, The Food and Agriculture Organization estimates it was cultivated on about 26×10^6 hectares (6.4×10^7 acres), in more than 90 countries, with a worldwide harvest of 1.83×10^9 tones (1.80×10^9 long tons; 2.02×10^9 short tons). Brazil was the largest producer of sugar cane in the world. The next five major producers, in decreasing amounts of production, were India, China, Thailand, Pakistan, and Mexico.

The world demand for sugar is the primary driver of sugarcane agriculture. Cane accounts for 80% of sugar produced; most of the rest is made from sugar beets. Sugarcane predominantly grows in the tropical and subtropical regions (sugar beets grow in colder temperate regions). Other than sugar, products derived from sugarcane include falernum, molasses, rum, *cachaça* (a traditional spirit from

Brazil), bagasse, and ethanol. In some regions, people use sugarcane reeds to make pens, mats, screens, and thatch. The young, unexpanded inflorescence of *tebu telor* is eaten raw, steamed, or toasted, and prepared in various ways in certain island communities of Indonesia.

The Persians, followed by the Greeks, discovered the famous "reeds that produce honey without bees" in India between the 6th and 4th centuries BC. They adopted and then spread sugarcane agriculture Merchants began to trade in sugar from India, which was considered a luxury and an expensive spice. In the 18th century, sugarcane plantations began in Caribbean, South American, Indian Ocean and Pacific island nations and the need for laborers became a major driver of large human migrations, including slave labor and indentured servants [39]

2.6.1 Sugarcane bagasse:

Sugarcane Bagasse (SB or bagasse) is the biomass that is studied in this project. Bagasse is the crushed remnants of sugarcane after syrup extraction. Sugarcane is a type of grass with peripheral fibers enclosing a soft central pith (Sugarcane utilizes solar energy by means of photosynthesis, to grow and therefore produce biomass. During photosynthesis CO_2 is extracted from the air and this CO_2 is released back into the atmosphere during combustion rendering the whole process CO_2 neutral. This energy is then released either by means of natural decay, or it can be harvested by means of controlled combustion or chemical reactions. Sugarcane is the crop that produces the highest yield of biomass over an average year. Up to 8 tons/acre of carbohydrate (sugar and bagasse) can be produced annually .Sugarcane is a fibrous plant which causes the crushed remnants to be thin long particles that are interwoven with each other. Therefore bagasse has very poor flow characteristics and it tends to bunch together. Additional size reduction before pyrolysis will enhance the flow ability of bagasse.

2.6.2 Sugarcane bagasse as the fuel:

Bagasse is mainly used for onsite combustion .The remainder is typically used to produce paper pulp, chemical reactants, or animal feed additives. Implementing

Thermo-chemical processing of bagasse will extend its uses to high-density energy products (char and bio oil)[39] as well as activated carbon and high quality fertilizer (from char). Bagasse is a by-product from the sugar industry and is therefore a second-generation biofuel, which implies that it does not compete with food crop production. Sacrificing agricultural land for fuel production may in the future become viable if fuel prices increase significantly.

2.7 The present studies in gasification:

The syngas produced from coal/biomass gasification can be used to generate electricity in a gas turbine and synthesize hydrocarbon fuels and other high-value chemicals. Gasification is one of most promising routes to cope with the variability of fuel quality for energy supply as well as to decrease pollutant emissions. Power generation based on biomass gasification would generally feature high reactivity and, more importantly, low net greenhouse gas emissions. However, biomasses tend to give high volatile yields (80 wt. % or more on the dry basis). The incomplete reforming of these volatiles will result in high concentrations of tarry materials in the gasification product gas, limiting the use of the product gas. The popular and commercial method to remove tarry materials from product gas is scrubbing with a liquid such as water, which not only is a complicated unit operation but would [40]produce a wastewater stream that must be further treated [33, 41]. Therefore, the removal of tarry materials from the gasification product gas is normally a very costly operation, amounting to a significant fraction of the overall gasification capital and operating costs reducing the cost of gas cleaning, especially the removal of tar is a major means to reduce the overall cost of biomass gasification.

The reactions of char and volatiles produced during biomass gasification are two core factors to control the whole gasification process. The interactions between the char and the volatiles can impact on every aspect of biomass gasification, including the char structural characteristics [42] and the volatilization of their inherent alkali and alkaline earth metallic (AAEM) species [40]. Enhanced interactions between volatiles and char would make char more stable[43] and enhance the volatilization of AAEM Species [24]–[44], leading to the deactivation and slow gasification of char. In order to achieve higher char conversion, a larger gasifier would be required, which would in turn increase the construction and operation costs. Minimizing the adverse impacts of volatile– char interactions to improve the char reactivity should become a major consideration in the development of new biomass gasification technologies.

In a practical gasifier, oxygen must be supplied into the gasifier to generate the heat required for the operation of the gasifier, especially the heat demand of endothermic gasification/reforming reactions. In many biomass gasification technologies being developed, the supply and consumption of O_2 (air) is a major issue [33]. Oxygen is frequently consumed mainly by the reactive volatiles, leaving the less reactive char to be gasified with H_2O and CO_2. The gasification of char becomes the rate-limiting step. Much more oxygen (air) than the theoretical oxygen demand has to be supplied to achieve a reasonable level of char gasification (and volatile reforming), resulting in low efficiency. The heating value of the gasification product gas is also low because it contains excessive amounts of combustion products (CO2 and H2O) and it is diluted by N2 as part of the air fed into the gasifier. Therefore, minimizing the air (O2) consumption should be another key consideration of new gasification technology development.

2.8Current studies in biomass gasification:

In this work a kinetic model is employed to describe the various stages of gasification process (e.g. drying, pyrolysis, combustion, reduction). The model includes reaction kinetics for the fuel drying and devitalization as well as ad hoc kinetics for two-phase flow. This allows to evaluate concentration profiles of all the species that take part in the various reactions and temperature profiles of both solid phase and gas phase along the reactor. The biomass fed in the reactor is regarded as a mixture of char, volatile matter, water and ash:

Biomass$_=$ Char +volatile + H2o (l) + Ash

The gasifier has a plain cylindrical shape and a finite volume method (FVM) has been utilized to divide the reactor in a multitude of infinitesimal elements of volume equal to the product of the section of the reactor for the height z of the cell. The one dimensional problem formulation for packed-beds is usually sufficiently accurate to describe all the phenomena acting in the reactors without introducing radial derivatives, at least as a first modeling approach [45]. As suggested by several other researchers the bed void section can withstand only minimal variations, in our case, and therefore it is supposed to be constant [46]. The power losses in a solar-reactor are principally due to the cavity receiver efficiency, to re-radiation and reflection losses as well as cold-surface radiation losses [45]. In this study heating losses are not considered. The radiation flux inside the reactor will refer then to an after-losses net energy flux.

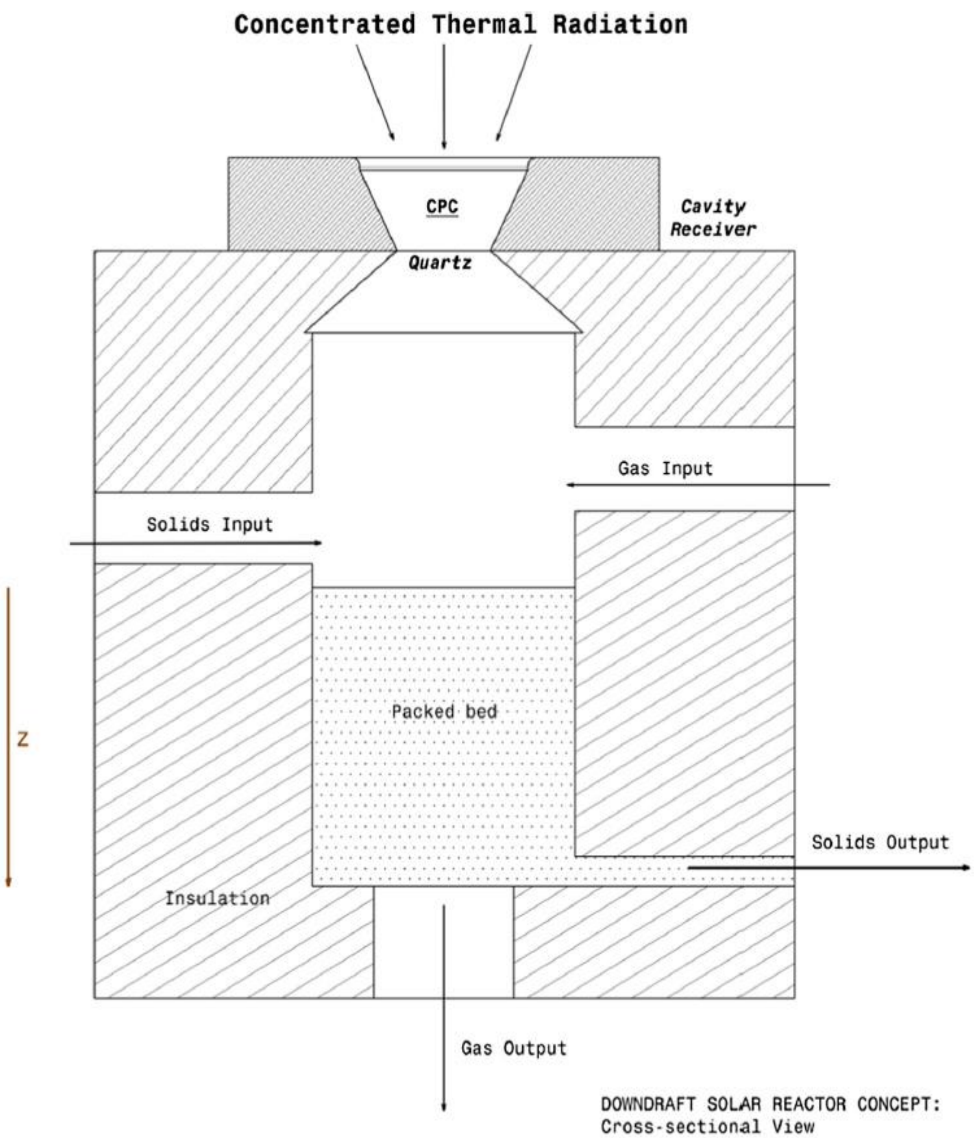


Fig. 1. Schematic of solar gasification reactor.

Figure (2.11) Schematic of solar gasification reactor.

In this study, some agricultural biomass samples such as sunflower shell, pinecone, rapeseed, cotton refuse and olive refuse were used. All of these biomass samples are highly abundant in Turkey and have low economic value. Cotton and olive are some of the most valuable agricultural products of Mediterranean countries. Sunflower, olive and rapeseed are widely used to produce vegetable oil in the western part of Turkey.

The proximate analysis and the calorific value measurements of the samples were performed according to ASTM standards, Ultimate analyses of the samples were performed using a EuroEA3000 model elemental analyzer. The pyrolysis of the biomass samples and then the gasification of the chars obtained from the pyrolysis were performed using the thermogravimetric analysis (TGA) technique. For the Thermogravimetric analyses, the biomass samples were initially ground and sieved to a powder with a particle size of <0.250 mm. The thermogravimetric analysis experiments were performed using a Shimadzu TG 41 analyzer. In order to avoid heat and mass transfer limitations, the masses of the original biomass samples were selected as only 40 mg. The samples were spread uniformly on the bottom of the crucible made of alumina. The pyrolysis of the biomass samples was performed at a constant heating rate of 20 K/min under a dynamic nitrogen atmosphere. During the experiments, the flow rate of nitrogen was fixed at 40 cm3 min_1 both to supply an inert atmosphere and to avoid the interaction of the pyrolysis products with the remaining char. The temperature was raised from ambient to 413 K and held for 10 min to be sure of complete removal of the moisture content of the samples and then raised to 1273 K and held 30 min at this temperature. After completion of the pyrolysis process, the obtained char was allowed to cool to ambient temperature under the dynamic nitrogen atmosphere of 40 cm3 min_1. The cooled char was then heated to 1273 K in order to gasify it under the dynamic atmosphere of 40 cm3 min_1 of the mixture of steam and nitrogen in equal volumetric ratio. At 1273 K, the temperature was fixed for 10 min. Steam was fed to the system at a fixed temperature of 353 K. All experiments were performed under atmospheric pressure. [47] reported that if pyrolysis is performed under inert conditions, the steam gasification reactivity of the chars is unaffected by pyrolysis pressure. Furthermore, CO and H2 play important inhibiting roles on the gasification yield at elevated pressures [48]. Derivative thermogravimetric (DTG) profiles of the samples, which show the rate of loss in mass versus temperature, were derived from the TGA curves. Thus, the effect of temperature on the rate of mass losses in the sample resulting from decomposition and the release of the products during pyrolysis and gasification were examined. The reproducibility of the experimental results was checked and errors were lower than 5%. Each data given was the mean value of at least two trials, or even more, whenever deviations were higher.

CHAPTR THREE

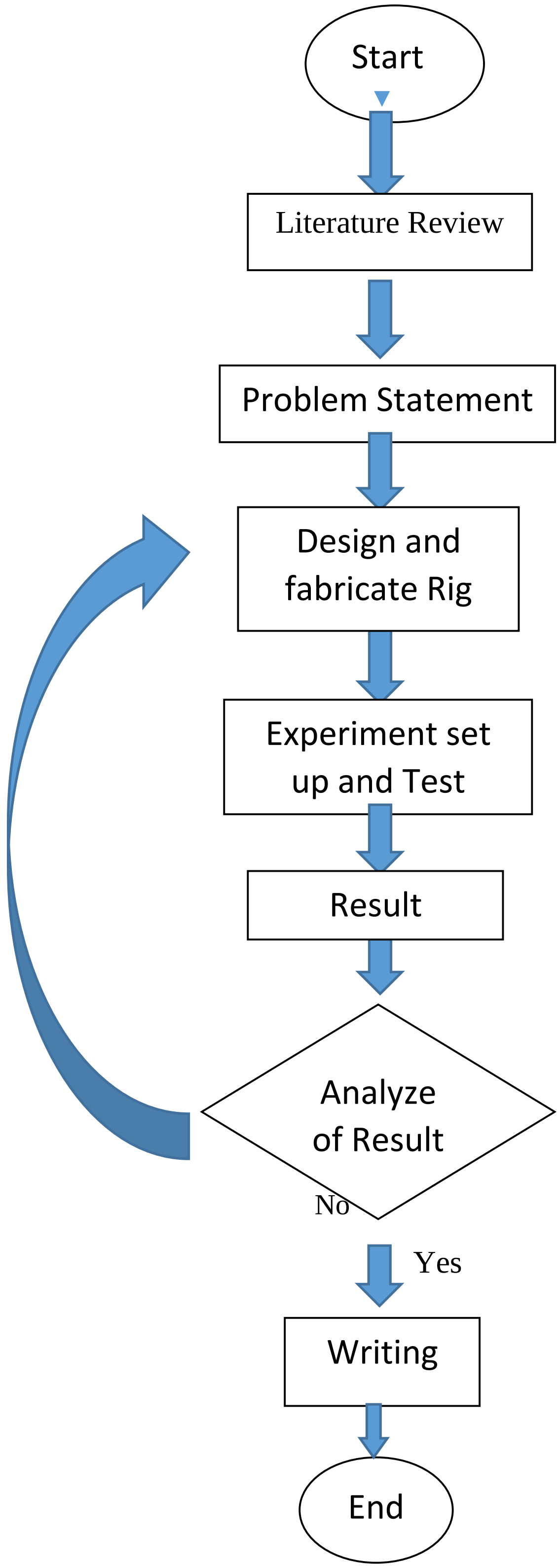
METHODOLOGY

METHODOLOGY

3.1 Introduction:

In this experiment we use the process of gasification for biomass, sugar cane residues after drying and grinding. The convert's organic based carbonaceous materials (sugarcane bagasse) in to nitrogen space area. This is achieved by reacting the material at high temperatures and without direct combustion for the material .In this we explore the use of a different kinds of organic wastes (sugarcane bagasse) from Kenna Sugar Company and White Nile Company by Updraft gasifier reactor to get source of power and primary material to get alcohol, gasoline, and diesel and jet fuel. To reach a higher efficiency for the reactor it is necessary to know effect of all parameters for gasification process.

3.2 Flow chart for project:



3.3Design and construction:

3.3.1 Burner:

As we know that the process of gasification need the temperature surrounding the cylinder so we built a small building dimensions as (1.2mx1.2mx1m) to reduce the leakage of heat out and maintain as much as we can to accelerate the process of interaction.

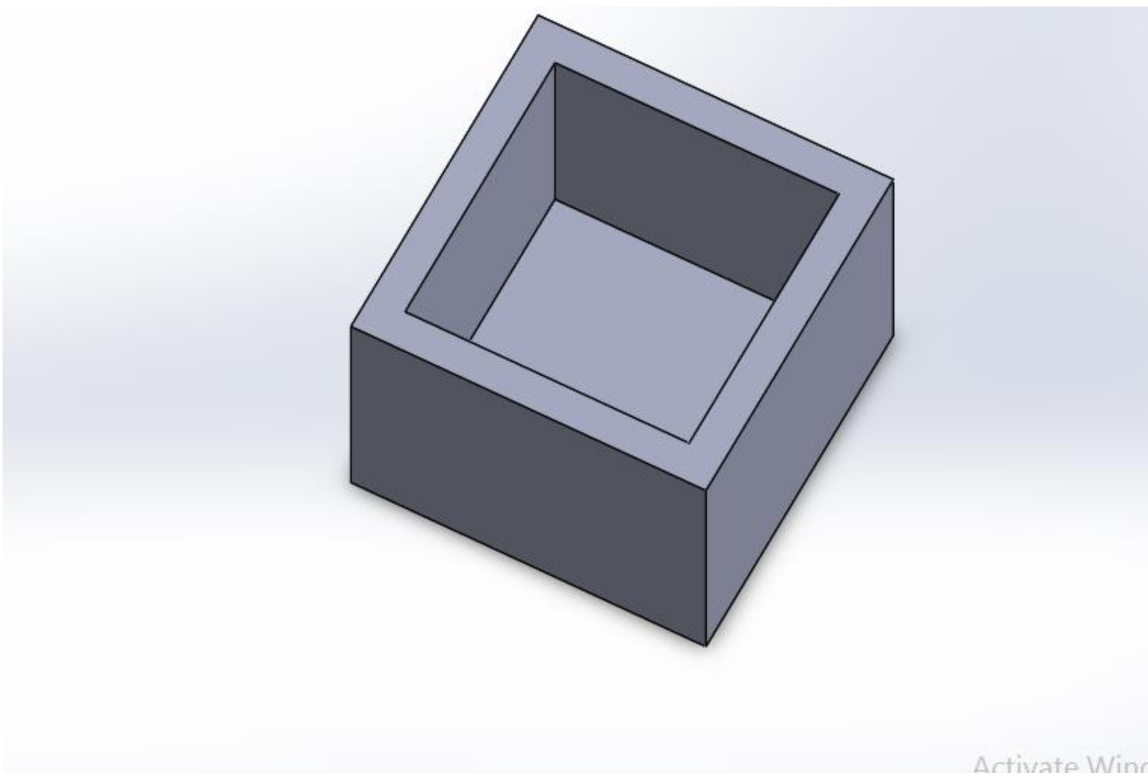


Figure (3.1) Burner

Figure (3.2)   Burner of gasification process

3.3.2 Cylinders:

We put the bagasse in it and the process of gasification complete in it and the dimension (0.3cm x0.6cm).

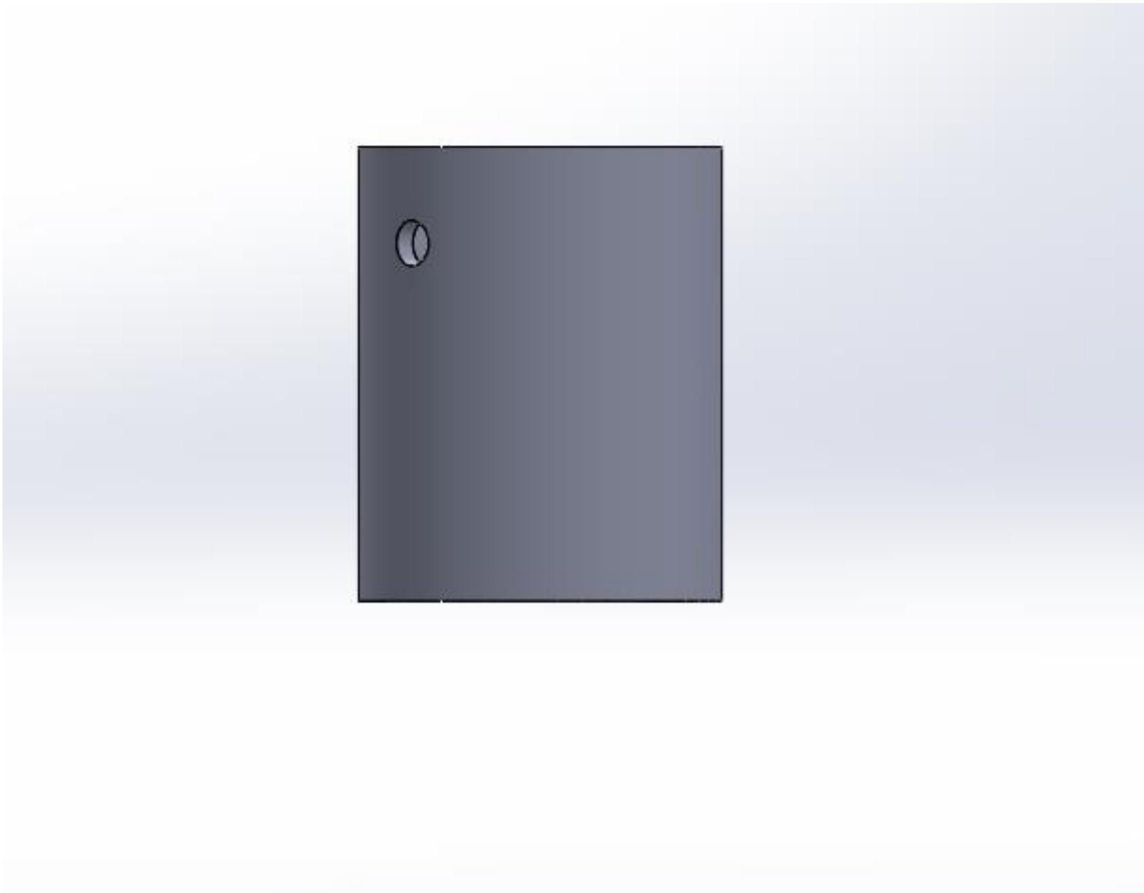


Figure (3.3) The cylinder (gasified)

3.3.3pipe:

We use it to two objective one of it to enter inactive gas (Nitrogen) and other objective to out the gas from experiment.

Figure (3.4) Pipe of input and out gases

3.3.4 Cover of cylinder:

Use to covering the cylinder and doesn't spill the gas to outside and close it as much as we can to prevent the spill of gas.

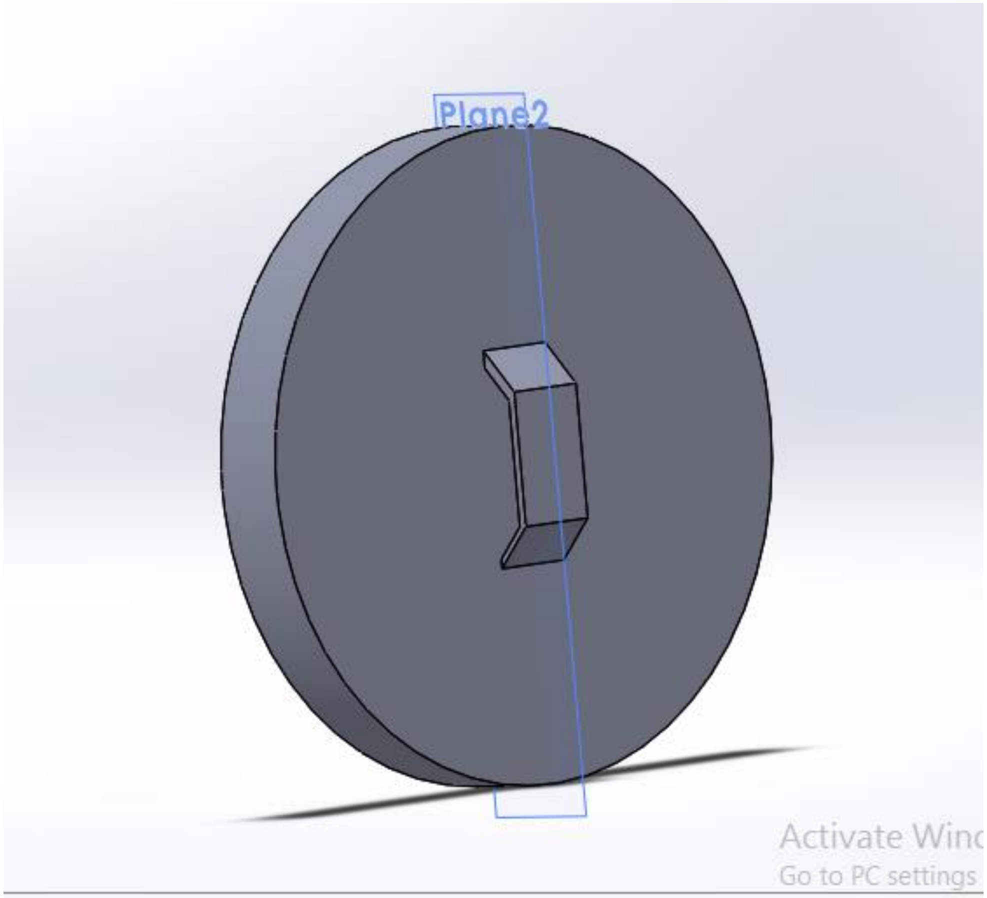


Figure (3.5) cover of gasifer

3.3.5 Gas tank (N2):

We entered the nitrogen gas (inactive gas) into the cylinder to maintain the distributed combustion anywhere in the cylinder.

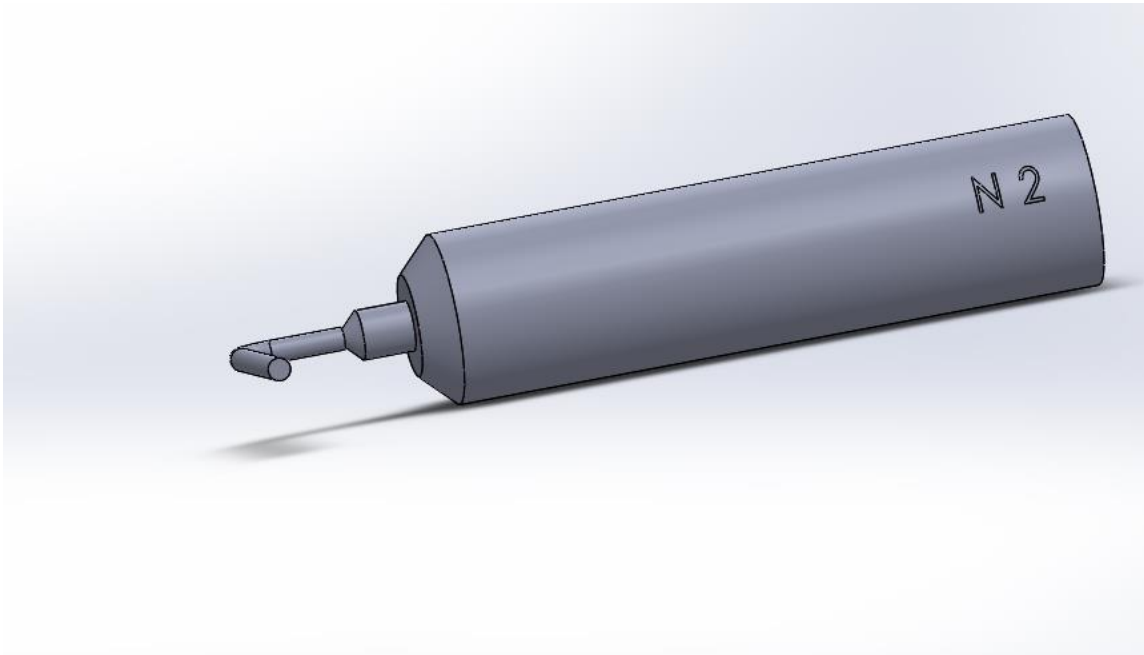


Figure (3.6) gas tank (Nitrogen)

3.4 pipe system:

The gas of nitrogen enter form the tank to cylinder throw pipe line as show in figure [Fig3.4], after gasification process get the row gas exit form anther pipe line as shown in figure [Fig3.4].

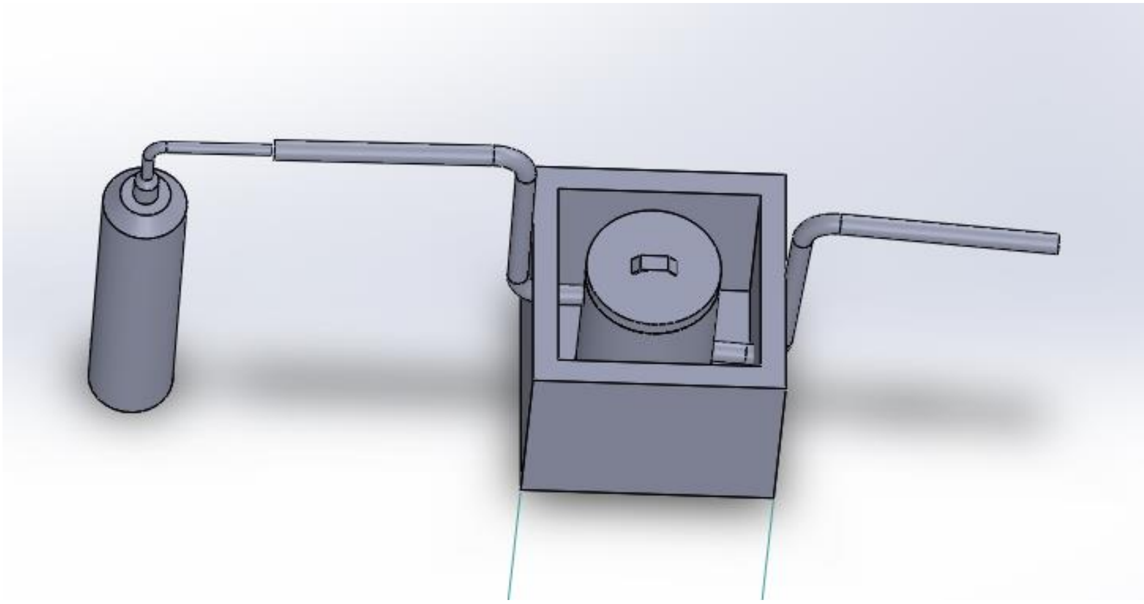


Figure (3.7) Final Design

3.5 Bagasse:-

Two different batches of bagasse were used for experiment. All bagasse supplied by the Kana Sugar company and White Nile Company in western of Sudan. The characteristic is from (48-52) %wt and heating value 46MJ/Kg.

Figure (3.8) bagasse sample

3.6 Gas anlayizer:

Figure (3.9) Gas analyizer

3.7 The procedures of experiment:

In this experiment, biomass gasification will be used, which is a bagasse waste, by heating to a temperature of 700-800 °c. The process begins by placing a sample of sugar cane residues in the cylinder and closing it well.

In the next step, we put the cylinder inside the incinerator and then set the fire on the sides of the cylinder. Then we insert the nitrogen gas into the cylinder through the bottom tube where the insulation is done so that the sample does not burn completely while the upper tube is closed.

Gasification is carried out in several stages: pyrolysis, gasification and partial combustion. It is important to provide the process with the heat required by the heat-absorbing reactions.

After about half an hour of continuous heating of the system, we observe that the flammable gases are confirmed by opening the valve located at the end of the upper incandescent and igniting near the valve nozzle to see the gases coming out of the cylinder.

CHAPTER FOUR
RESULT AND DISCUSSION

RESULT AND DISCUSSION

4.1 Introduction:

This chapter presents the experimental results obtained using the method and equipment described in chapter 3. The design and construction of the process is shown in Section One, followed by results obtained from experiments at different process parameters as shown in Section Two.

4.2 The complete design of gasification process:

Figure (4.1)

4.3 Experimental result and discussion:

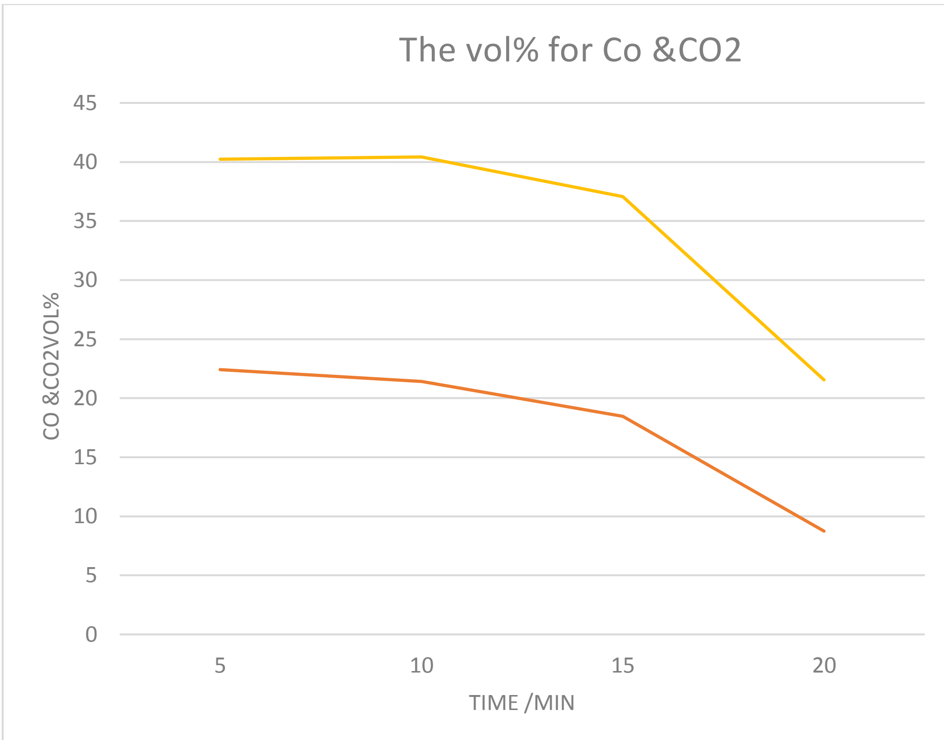


Figure 4.2 the relation between Co&CO2 with time

Figure shown above explain in X axis time /min and the Y axis show the Vol% of Co &CO2. The change in temperature depends on the type of reaction. Is it repellent or heat resistant? If the change is negative, it is a heat-reactive reaction.

The reason of less of carbon dioxide is that the oxygen is increase or stable at the atmosphere.

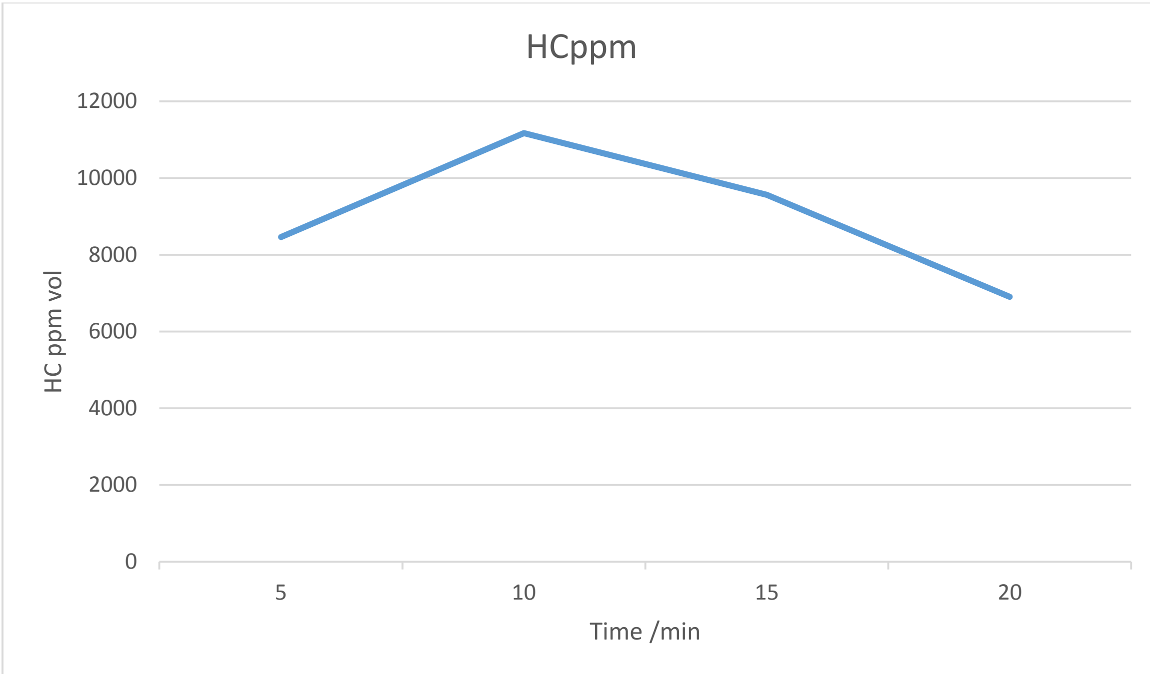


Figure (4.3) the relation between HC with time

The figure shown above explain in X axis show the time per min and in Y axis show the ppm vole for the hydrocarbon in process. Hydrocarbon is one of the saturated compounds and when the combustion is complete we get the highest point in the combustion and then the temperature begins to decline gradually depending on the impact of atmospheric pressure and the surrounding medium. The effect of nitrogen gas on hydrocarbons in the gas when it reaches the highest point. This indicates that the combustion is not complete and that at the beginning and after the continuation of the interaction began to decrease this indicates the validity of the reaction.

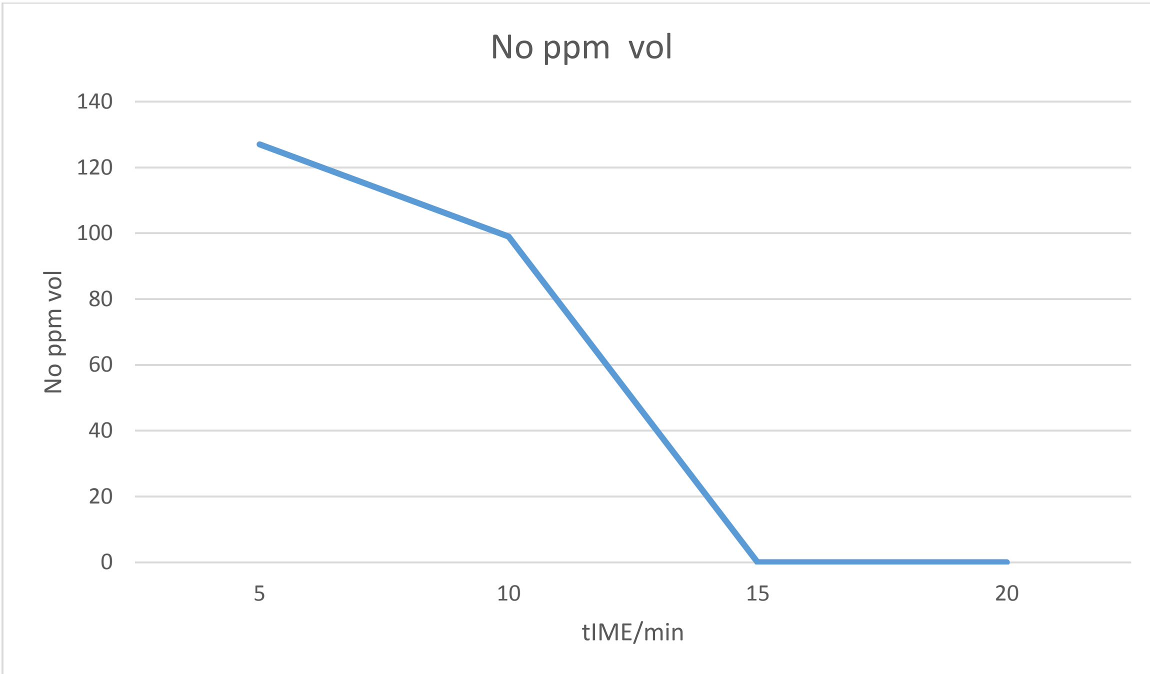


Figure (4.4) the relation between No with time

The figure shown above explain X axis time per min and Y axis ppm vol for Nitrogen oxide The aim of the inert gas nitrogen gas is that the higher its effect the lower the temperature inside the cylinder that the combustion was equal in all parts of the cylinder and make the flame high at the same time . Nitrogen gas does not enter the reaction, but its contribution to nitrogen atoms with oxygen air is the first nitrogen oxide and because the association between them is weak after the interaction, the first nitrogen oxide will disappear.

4.4 Visual inspection:

Fig (4.5) shown above explain the flame of syngas that produced of gasification process which it content of hydrocarbon.

Figure (4.5) flame of burned syngas

CHARTER FIVE

CONCLUSION AND RECOMMENDATION

CONCLUSION AND RECOMMENDATION

5.1 Conclusion:

After many experiments, can Sayed that the model used is a simplified and sufficient model for experiments. Therefore, the following can be achieved:

- The study of the bagasse and determining its desired form to be used in this model.
- The required gas is obtained (combustible hydrocarbons).
- Find the relationship between the gases that make up the thread with time.

5.2 Recommendations:

On the basis of information gained uncompleted this project, these recommendations are suggested:

- Conduct many experiments using different types of bagasse to compare them and identify differences.
- Intensification of visits to entities that use sugar cane residues to generate energy.
- The possibility of modification in the model by adding a mechanism or system that works to purify the resulting gas.
- Modifican in the Holocaust to increase its effectiveness in order to obtain adequate temperature.
- Final product can be primary material for CH4,H2 and bio fuel.

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