Conceptual Design of Fluidized Dual Bed Gasification System

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Abstract:

Conceptual Design is an initial stage of the design procedure, in that procedure, the broad outlines of function and form are designed. It involves an understanding of people's needs - and how to encounter them with products, services, & processes. Biomass is one among the renewable, potentially bearable energy resources and has many possible applications. A fluidized-bed's uncontaminated stream delivered by the biomass gasification progression which is a highly endothermic process that has been linked in numerous ways to a fluidized-bed combustor to blister the char that is produced in the gasifier. This type of gasifier is called as dual fluidized-bed (DFB) biomass gasifiers. Dual Fluidized Bed gasifier is widely used, and it is focused on a feedstock. The thought-provoking aspect of the work is to eradicate the tar content from the producer gas in which it would obstruct all the working components of the gasifier and the engines where it is being used.

Keywords: *biomass; conceptual design; combustor; dual fluidized bed gasifiers; endothermic process; feedstock; tar.*

1. Introduction

Decisions made during conceptual design have a substantial impact on the cost, recital, dependability, safety, and environmental bearing of a product. It has been valued that design choices account for more than 75% of final product costs. It is, then, bouncing that designers have access to use the right tackles to support such design doings. In the 1980s, investigators began to understand the effect of design decisions on downstream doings. As a result, different practices such as design for assembly, design for manufacturing, and contemporaneous engineering, have been projected. Software tools that implement these practices have also been established. However, most of these tools are only appropriate in the comprehensive design phase. Yet, even the highest average of detailed design cannot reimburse for a poor design perception framed at the conceptual design phase.

Even today the world is in rapid growth and change demanding an adequate energy source besides fuels like firewood and petroleum. Later, Biomass is used widely as an energy cause. In emerging countries like Ethiopia where most of the populace live in rustic communities, Biomass is a main source of vigor for cooking and lighting purposes, but its manufacturing use is limited [1].

Recently, Biomass also being used in solid form is being converted into gassy form through the gasification process, this process of conversion is named as gasification. The chemistry behindhand the process is to thermally convert the biomass into combustible gas, where producer gas might be of low, medium, or high calorific value contingent on the process used in gasification [2]. Biomass is the major bearable energy capitals in the world and has been professed as an attractive cause for the manufacture of power, fuels and other chemical products. Though, the immense and troublesome form of biomass is a major blockade to its wide bids, so that it affords an inspiration for changing solid biomass into either-or liquid fuels or vaporous fuels.

The basic structure of the fluidized bed gasifiers entails various parts such as upright, tube-shaped, refractory-lined vessels attached with recycle cyclones and having an ash cooling system at the bottommost part of the gasifier. A lump of fine dry coal which is less than 6 mm is provided at the bottommost of the gasifier and then it is fluidized with the vapor and oxidant [4]. Heat and mass transfer transpires by enormously clad mixing of feed and oxidant [5]. The operational spells in the gasifier are maximum in the order of 10 to 100 seconds, so that the feed undergoing a high heating rate while towards the inside part of the gasifier it is instigated because of the even dispersal of feed in the bed, by doing so we are getting a certain amount of partly reacted fuel which is removed with the ash content by placing the control on the transformation of carbon. Some unreacted particles that are entrained by the gas are recovered by recycling cyclones.Dual fluidized bed gasifier also called fast internally CFB skill is a theoretically proven skill that has already been applied at the demonstration scale and has been identified as an auspicious biomass gasification technology, exclusively for the manufacturing of high-quality syngas [6].

An in-depth description and analysis of Dual Fluidized Bed Gasification technology can be found in several recent evaluations and relevant trade studies. DFBGs are fundamentally composed of two unified fluidized bed (FB) reactors: an endothermal FB gasifier using vapor as the gasifying mediator and an exothermal FB combustor providing the heat for the gasifier by mingling the bed material. Biomass is at first gasified in the FB gasifier, and the ungasified char is combusted in the FB combustor. Among the various possible designs of Dual Fluidized Bed Gasifiers, the combination of a Bubbling Fluidized Bed for the biomass gasification with a Circulating Fluidized Bed for the char combustion has been recognized as the best practical choice for biomass gasification in terms of fuel conversion and tar production [6].

2. Characteristics of biomass

2.1 Moisture level

In the gasification process moisture level is a significant factor that sanities much of deliverable energy from the gasification plant this form of energy is used only for desertion. It is stated that the amount of water content in the solid fuel is a fraction of the fuel weight. This fuel weight can be of three types such as based on a wet basis, dry basis, dry-and-ash basis. [7].

2.2 Ash Content

The remaining component formed after the combustion of biomass is referred to as ash which is inorganic in nature. It is uttered as same as the moisture level. Melted ash may cause many root glitches in the reactor therefore this property is especially run under high-temperature gasification process [7].

2.3 Composition of biomass elements

The biomass is unruffled of various components such as carbon, oxygen, hydrogen and a small volume of nitrogen and Sulphur. This ash-free organic composition of biomass is uniform [7]. Table 1 exemplifies the weight percentage of dry and ash-free based biomass composition [20].

Table 1. Elemental Composition of Typical Biomass

Biomass Elements	Weight percentage (dry and ash-free based biomass)
Carbon(C)	44-51
Hydrogen(H)	5.5-6.7
Oxygen(O)	41-50
Nitrogen(N)	0.12-0.60
Sulphur(S)	0-0.2

2.4 Energy Density

The possible energy accessible per unit capacity of the biomass is known as energy density. It is primarily dependent on bulk density and the heating value of the type of feedstock used. In common, the energy density of biomass is about $1/10^{th}$of that of fossil fuels [7]. In the combustion process, the organic matter in the mixtures of carbohydrate and carbonaceous fractions (pods) is transformed into CO_2 and water, and a small amount of CO, NO, and some unpredictable organic mixtures are produced and leave the furnace along with the flue gases. Table 2 shows some types of biomass sources and their heating value, corresponding moisture, and ash contents in percentage.

Table 2.Typical characteristics of different biomass fuel types

Type of biomass used	Lower Heating Value (kJ/kg)	Moisture Content in percentage (%)	Ash Content (dry) in percentage (%)
Bagasse	7,700-8,000	40-60	1.7-3.8
Rice husk	14,000	9	19
Wood	8,400-17,000	10-60	0.25-1.7
Gin trash	14,000	9	12
Stalks	16,000	10-20	0.1
Coffee husk	16,400	509	11.4
Bamboo	15,000-18,000	Not measured	3.41
Prosopies	18,000-23,000	5.7	1.4
Eucalyptus	16,000-18,000	3.9	2.2

2.5 Content of volatile Matter

Volatile matter is defined as heated biomass which is unconfined during the gasification process. The feedstock used in biomass comprises a very high amount of volatile material of 70 to 90% which is organic in nature [8].

3. Gasification Process

The core of a gasification procedure is converting solid fuels like carbon into various gases mainly carbon monoxide and hydrogen, by using a combined thermal- chemical process [9] which is shown in the universal formulation as an Equation 1.

Biomass+ Oxygen (or Water)

- CO, CO_2, H, CH_4 + other Hydrocarbonsformed in the gasification process
- Biomass = Producer gas +Flue gases +Tar +Char + Ash (1)

All gasifiers are parted into dissimilar zones which is conceptually vital but not in reality. Five distinct thermal processes complicated in gasification are drying, pyrolysis, combustion, cracking, and reduction.

Drying → Pyrolysis → Combustion → Cracking → Reduction

- Drying is a process in which humidity is dissolved from the solid fuel.
- Pyrolysis otherwise called thermal filth in this process volatile materials are distilled to produce char, tar, and non-condensable gases.
- Combustion is a process of changing solid fuel into gaseous products such as carbon dioxide and water to supply the energy required for nourishing a certain operating temperature.
- Cracking is the process of substantial hydrocarbon particles broken into a lighter one.
- Reduction is a process in that CO_2 is abridged to Carbon to form two Carbon Monoxide molecules.
- Gas-phase pyrolysis/gasification of tars.

Gasification is just the knowledge to pull separately and segregate the processes so that the "fire" is influenced to be sporadic and resulting in product gas in the pipes [10]. An amalgamation of numerous individual processes that take place in series and or in parallel in a gasifier is desire as biomass gasification.

4. Conceptual Design Proposal

Other than this, few tools of Computer-Aided Design have been industrialized to sustenance conceptual proposal activities. This is since the information of proposal necessities and limitations throughout the initial phase of a product's life cycle which is usually vague and imperfect, and it is difficult to utilize computer-based systems or its prototypes.

However, recent improvements in fields like fuzzy logic, computational geometry, constraints programming, and soon have now made it possible for investigators to trial some of the issues in dealing with conceptual proposal activities represents in Figure 1.

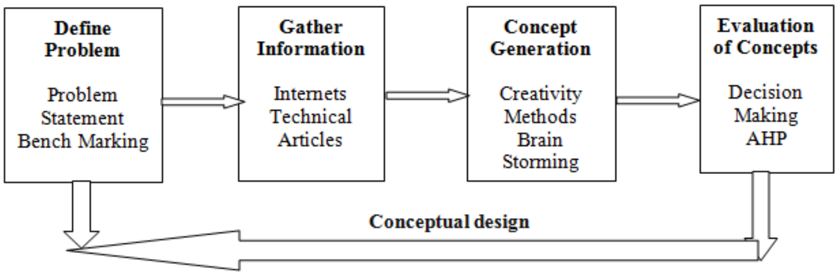

Figure 1. Conceptual Design Stages

In accumulation to this, there are several features of the conceptual design stage available: from the seizing of the inventor's intent, to model design limits and solving them in a well-organized manner, to confirming the perfection of the design.Its conceptual Scheme of DFBG is represents in Figure 2.

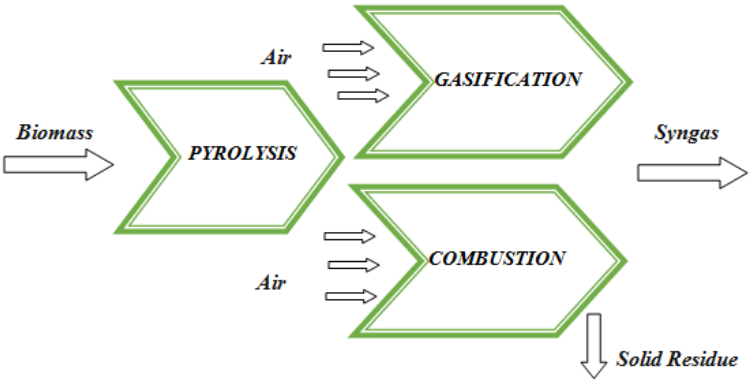

Figure 2.Conceptual Scheme of Fluidized Dual Bed Gasification System

4.1 Define Problem

The foremost stage in conceptual design. In biomass gasification expertise development of tar is a major problem and it would be benchmarked and resolved.

4.2 Gather Information

The second stage of conceptual design in gathering information about all types of gasifiers and its working functions, in these gasifiers, every single stage is auto thermal. We can't able to diminish the tar production just by air staging strategy; Self-reliant energy is also formed. Heat for pyrolysis is providing the incomplete oxidation of the solid biomass fuel in its oxidative surroundings. [11]

4.3 Concept Generation

In the concept generation stage, we are considering various optimal operation parameters such as element size and Biomass Temperature which influence the efficiency of the gasifier. By considering these parameters a two-stage gasifier is advanced in that pyrolysis and oxidation stages get separated [11].

4.4 Evaluation of Concepts

In Concept evaluation present study, the optimal operation parameters such as particle size and biomass temperature and we are investigating various factors such as low heat value of the fuel gas, its production rate, its efficiency, and its carbon conversion that influences the tar production. The system is self-possessed by three different stages: pyrolysis, combustion, and gasification as represented in Figure.3.

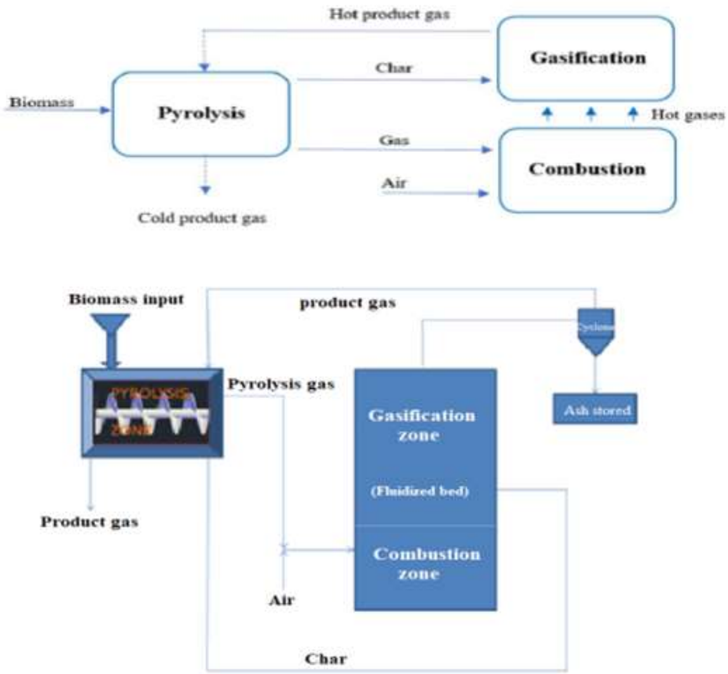

Figure 3.Stages of Gasification

Firstly, biomass is heated in the pyrolysis bed to produce pyrolysis gas and char. Pyrolysis gas will be seared in the combustion chamber and char will be nourished to gasification bed. The fluidized gasification bed is a blend of char and sand. Secondly, through a gas provider, hot gases are nursed from the combustion chamber to the fluidized bed to produce a hot product gas (expected at about 800°C - 1000 °C).

Finally, gas is passed to the pyrolizer to afford exterior heating for pyrolysis and for sustaining reactions thereby heat conversation is caused between the product gas and pyrolysis zone.

Therefore, related to classical Dual Fluidized Bed Gasification, as a replacement of burning char, pyrolyzed gas will be burnt. Hot gases formed will be the gasification negotiator instead of using an additional preheated one. Figure.4 shows the system design indicating its three zones. The proposal intends to develop an inimitable gasification technology with high fuel litheness as that of a fluidized bed gasifier and to lower the tar contents.

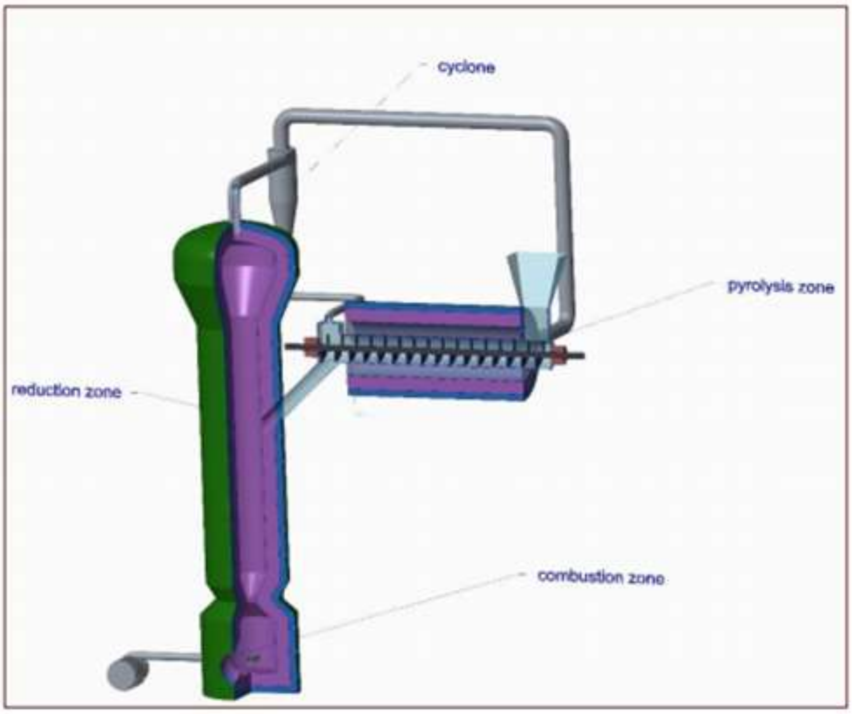

Figure 4. System design indicating its three zones

5. Conclusion

The Conceptual Design proposal is to maximize the probability of a feasible final invention. Hence, a conceptually designed proposal should be worked with adequate detail which allows us to estimate the cost, weight, complete proportions, and power consumption. The probability of design decisions or their substitutions should be legalized through prearranged sub-system tests. Based on the conceptual design and study over various deliberation in a gasification process, tar content is a foremost problem in overall gasifiers and in order to minimize the formation of tar the design is to be modified, so that gasification arrangement is to be divided into two sectors by separating pyrolysis in a single region so that we can diminish the formation of tar, for that the fluidized gasifier is designed in dual-stage.

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