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BIOMASS ENERGY CONVERSION: A REVIEW IN INDIA PERSPECTIVE

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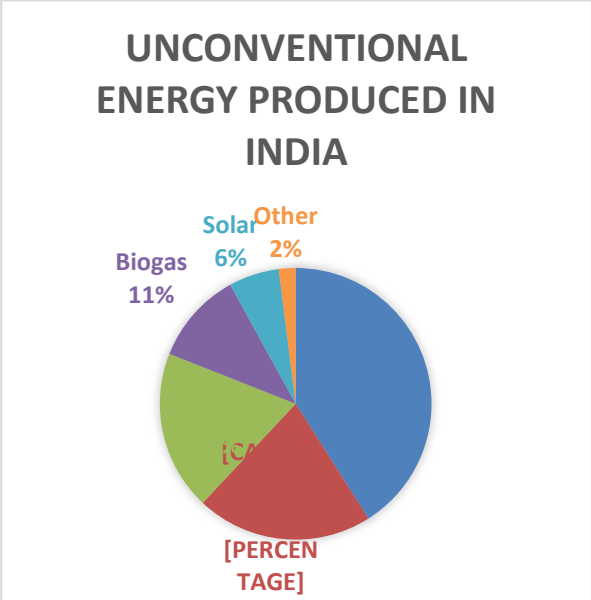
Abstract: In this paper an innovative method of producing energy from biomass has been implemented using process heat and fractional distillation. The overall efficiency of conversion can be increased by applying this method. Biomass is a biological ingredient derived from carbonaceous waste of various natural and human day to day activities. India is a densely populated country. Large number of people residing in rural areas harvest fire wood, vegetation, animal dung and agricultural residues for domestic cooking. In this research, the available sources and potential of biomass fuels in India are studied, and converted into power very efficiently on the basis of available information.

Keywords: Biomass, Process heat, Agricultural leftovers, Energy, Fractional distillation, India.

I. INTRODUCTION

Biomass is an exemplary source of energy ranked 4th only after oil, coal and natural gas. Almost 15% of the world's total energy is obtained from biomass and accounts for nearly 10% of the global primary energy supply. In developing countries, 35% of the energy utilized for cooking and heating is derived from biomass. The pie chart depicts unconventional energy produced in India such as Solar energy, Wind energy, energy from biomass, Hydro energy etc.

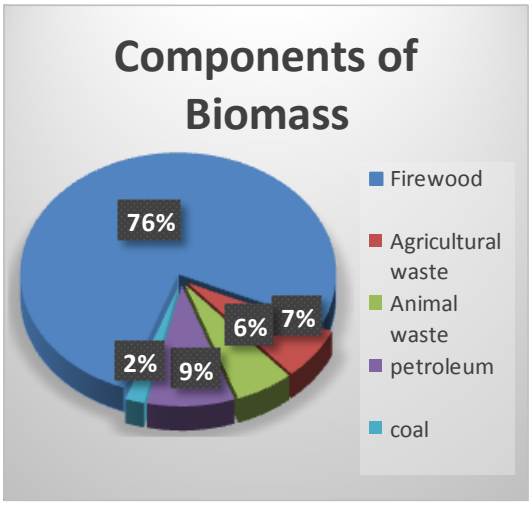


Source: EIA [Energy Information Administration]

Out of the entire unconventional energy produced, 19%of the energy is synthesized using biomass. In the following sections a brief overview of modified process is given by which this percentage can be augmented.

II. COMPOSITION OF BIOMASS

Biomass can be majorly categorized into five materials:
1): Virgin wood (obtained from arboricultural activities, wood processing)
2): Energy crops (high yield crops cultivated for energy applications)
3): Agricultural residues
4): Food wastes
5): Industrial wastes and co products.
Components of biomass can be illustrated as:



Numerous sources of biomass are:

- Forestry residues
- Agricultural residues
- Sewage
- Industrial wastes
- Municipal Solid Waste(MSW)
- Animal husbandry residues
- Food processing wastes

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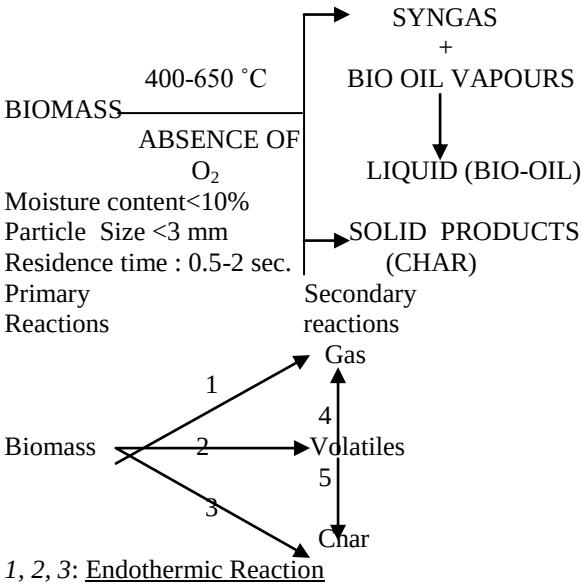
- Agro-industrial wastes

III. CONVERSION PROCESS

SEGREGATION OF UNSOLICITED GASES

PYROLYSIS OF DREGS: pyrolysis of biomass is the thermal decomposition of biomass in oxygen-starved chamber. Pyrolysis of the residue proceeds through a chain of reactions yielding various products. The products include bio-char, bio-oil and gases such as methane [CH_4], hydrogen [H_2], oxides of carbon and so on. The long chained carbon, oxygen and hydrogen compounds present in biomass are disintegrate into smaller molecules in form of gases, tars and oils, and solid charcoal (under pyrolysis conditions). The fast pyrolysis process is used widely. Fast pyrolysis results in 63% bio-oil, 18% bio char and 19% synthesized gases.



1, 2, 3: Endothermic Reaction
4, 5 : Exothermic Reaction

Manufacturing of BIOETHANOL: The process of fermentation of sugar from various forms of biomass is done, and the overwhelming proportion of ethanol produced is used as a fuel.
USES: production of ETBE (Ethyl Tertiary-Butyl Ether) and also used as bio based poly-ethene.
Manufacturing of SYNTHESIS GAS (carbon monoxide and hydrogen): By the process of high temperature gasification the solid biomass is converted into synthesis gas.

$$CH_4 + H_2O \rightleftarrows CO + 3H_2$$

USES: Various solvents, fuels, fertilizers and a wide range of synthetic materials have their origin in syn gas.
Manufacturing of AMMONIA: hydrogen from synthesis gas (produced by gasification) is converted into ammonia by HABER process by the addition of nitrogen from air.
USES: fertilizers
Manufacturing of BIOBASED ETHENE: Bioethanol and its de-hydration to ethene is done by the Haber's process in the presence of a catalyst. The ethanol is passed over the bed of catalyst with a temperature ranging from 600K-750K.Higher the temperature lesser is the chance for the formation of ethanol. The catalyst used for this process is a mixture of magnesium, aluminum and silicon oxides.

$$C_2H_5OH(g) \overset{\text{catalyst}}{\rightleftharpoons} C_2H_4(g) + H_2O(g) \qquad \Delta H^{\ominus} = +45\ \text{kJ mol}^{-1}$$

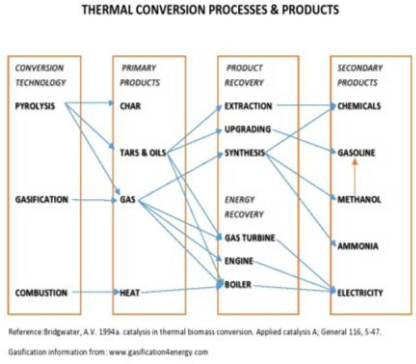
USES: Bio-polymers, chemicals and also as a bio-fuel.
Manufacturing of BIOBASED POLYETEHNE: Ethene is polymerized by the process of Bio-forming to produce polymer by the process of high temperature gasification.
USES: Bio based plastic.
Manufacturing of FUELS: Syn gas is transformed into a hydrocarbon waxby the FISCHER TROPSCH process (passing the vapor over a cobalt catalyst). The SHELL MIDDLE DISTILLATE SYNTHESIS (SMDS) is a newer development of this process. The hydrocarbon waxes are catalytically cracked with excess of hydrogen (hydro cracking) to form smaller alkanes.

$$C_{20}H_{42} + 2H_2 \longrightarrow C_8H_{18} + C_7H_{16} + C_5H_{12}$$

Uses: Smaller alkenes are used in liquid fuel, kerosene and naphtha depending on their volatility.
Manufacturing of METHANOL: The synthesis gas produced from gasification is converted into methanol by the application of high temperature and pressure with a catalyst.
USES: Plastic industry
Manufacturing of BIOBASED PROPENE(BIO-BASED PROPYLENE): Propene is prepared by the syn-gas and propan-1-ol. Carbon monoxide[CO] and hydrogen[H_2] is used to convert bioethanol to propan-1-ol via heating with ethanol over a catalyst. The catalyst used is a ruthenium-cobalt complex salt. To make it more resistant to poisoning by sulphur containing impurities in the feedstock, molybdenum based catalyst is also used. Now, the propan-1-ol is dehydrated to propene via dehydration process.

$$CH_2{=}CH_2 + CH_3CH{=}CHCH_3 \longrightarrow 2CH_3CH{=}CH_2$$

USES: Injections, textile etc.



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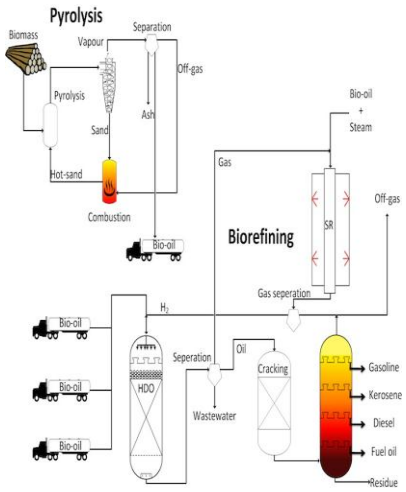


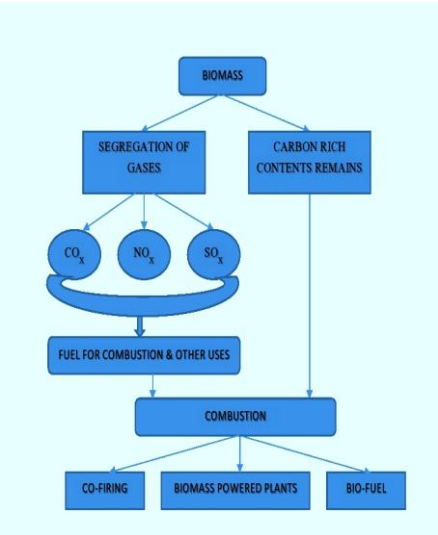
Conversion of biomass into bio-oil for power generation

Use of Process Heat:

The heat utilized in various decomposition and other chemical processes can be extracted from industries only in the form of process heat. Using process heat enhances the overall efficiency of the process.

No separate system for production of heat is to be installed but the heat produced from various processes already undergoing in the industry can be extracted. The process heat can be transferred directly or indirectly to the biomass chamber for pyrolysis.

The main drawback of process heat is that we cannot rely solely on process heat to meet the entire heat energy requirements. It is not very high in magnitude and another external heat source will be required. However, still the overall effect will prove to be vital for the industry. Another alternative can be to use the suitable techniques to optimize process heat.



Flowchart of biomass conversion process

IV. ADVANTAGES

Non-polluting and renewable energy sourcesaves firewood and fossil fuel adequate way to dispose the agricultural and human waste curtails landfills and cheaper source of energy scales down greenhouse effect leads to the improvement in environment, sanitation and hygiene source of employment generation biomass is easily and always available setting up of the new biogas plant can reduce the import of highly volatile fossil fuels provides manure for fields energy from biomass is impeccable compared to wind energy and solar energy.

V. DISADVANTAGES

Less advancement of technology
Process is not very alluring on industrial scale as compared to other fuels
contains some gases as impurities which are corrosive to the machine parts
not feasible to locate at all the sites
The agricultural waste is available only after the harvesting of the fields and that biomass can only stretch for 2-3 months in a year
Biomass energy cost is highly variable depending on the location, source etc.
Lack of biomass energy market is the main barrier for the application of modern biomass technologies.

VI . APPLICATIONS

The carbon concentrate remaining can be used for a variety of applications as a fuel. It can be used as a superior fuel in terms of power production. Also it can be used in direct fired systems such as co-firing.

As the biomass is richer in carbon, higher amounts of energy can be obtained than the conventional. The main applications are as follows:

- Synthesis gases and oils
- Pharmaceutical products
- Polymer products
- Eco fuels
- Electricity generation
- Chemical products

VII . FUTURE PERSPECTIVE

Biomass can prove to be one of the better alternatives of coal in terms of power production in future. Further:

- installation of biogas plants can meet the future energy requirement
- renewable energy like biogas can help in mitigating climate change
- can prove itself for sustainable development and health improvements in rural areas
- the summation of biomass-fuelled gasifiers and coal-fired energy generation would be beneficial in terms of improved flexibility in response to the fluctuations in biomass availability with lower investment costs

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- the future of the biomass energy depends on the advance technologies and the policies made by the government for its optimum utilization
- the modern technologies provide opportunities to convert biomass into liquid and gaseous fuels
- future of biogas energy depends majorly on availability of reliable energy services at reasonable cost
- potential availability of agro residues and wood processing waste in India can sustain 10,000 MW power

VIII . DISCUSSIONS AND CONCLUSIONS

As we know due to depleting reserves of fossil fuels (mainly coal, crude oil etc) the need to find an alternative source of power production is altitudinous. The use of biomass as a fuel does not only solve the energy crisis in the country but can also reduce environment abasement as compared to the conventional sources of energy production.

The energy sector of India needs to compete with proliferating energy deficiency. Given the humongous population of India and the modern trends of industrial and urban growth, the various sources of biomass will accrete. Research in area of biomass can also prove substantial in terms of sustainable development.

The biomass should not only be seen as a source of power production but also various by-products obtained by decomposition can be also used in an effective manner. Treating these products chemically, we can synthesize various that are of demand in industry such as refrigerants, spirits, combustible gases and so on.

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