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REVIEW ARTICLE

**ANALYSIS OF SOLAR STEAM GASIFICATION OF CARBON- RICH FLY ASH TO PRODUCE
 SYNTHETIC GAS.**

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Abstract

Converting waste material generated from various sources into syn gas and using it for power generation has emerged as means of converting abundantly available wastes into clean and efficient electrical energy. Solar thermal systems use focusing mirrors to concentrate the sun's rays and efficiently achieve ultra-high temperatures. The produced syngas can be burned in the oxidiser at temperature up to 700°F with flue gases to produce high-pressure steam that drives the turbine for producing electricity. The process produces a flexible product, synthesis gas, which can be chemically converted to a number of useful fuels (e.g. gasoline, diesel, hydrogen). This process is much faster (seconds vs. days), simpler, and has the potential to produce a wider range of chemical products. By 2030, world energy demand will climb from a current level of 18 TW to 28 TW. At the same time, concerns over the environmental and national security impacts of fossil fuel use are driving the search for a fuel source that is abundant, clean, and producible in India. Fuels produced from waste (e.g. switch grass, agricultural residues, forestry waste) could provide a large piece of this energy puzzle. This innovation proposes to use solar thermal energy to overcome the problems encountered in conventional conversion. Such an approach lies on the interface between two renewable energy technologies (solar and wastes) and is uniquely positioned to maximize the positive qualities of both.

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Introduction:-

The heat required for operating a conventional thermochemical gasifier is provided by combustion, either of a fossil fuel (e.g. natural gas) or of the feedstock itself. Obviously, processing with natural gas is neither renewable nor carbon-neutral, and the price will be strongly linked to the price and availability of natural gas. To maintain gasification temperatures between 500 °C and 800 °C, up to 30% of the resource material must be combusted. Reaching temperatures where conversion efficiency and selectivity are extremely high (1200 °C) require 35% -45% resource combustion, based on adiabatic flame temperature.

If natural gas is used, and equivalent amount of energy must be consumed to drive the gasification – it would make more sense to reform that fuel to syngas directly. High temperatures, at which conversion and selectivity have been shown to be improved, are expensive to attain, as too much of the feedstock must be used as fuel to maintain

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reaction temperatures. Solar thermal energy provides a means to efficiently and sustainably provide high temperature (>1000 °C) process heat while utilizing an abundant but underused renewable resource.

National Status:-

Conventional industrial processes depend on hydrocarbon resources for producing fuels like Hydrogen/syngas and commodities like metals, lime etc. These industrial processes are highly energy and carbon intensive. The issues of fossil fuel depletion and climate change have resulted in development of solar industrial process solutions. Concentrated solar technology offers the option of converting solar energy into thermal, electrical and chemical forms. While conventionally concentrated solar energy is used for process heat and power generation applications, using it to drive chemical reactions is remarkable.

Processes that make use of solar heat to drive high temperature endothermic chemical reactions are known as solar thermo chemical processes. Solid carbon feed can be steam gasified in the temperature range of 1123 - 1883 K to produce syngas. Concentrated solar energy can efficiently achieve temperatures where conversion and selectivity of gasification are high (1000°C – 1200 °C). Use of solar energy removes the need for a combustion fuel and upgrades the heating value of the waste products. The syngas product of the gasification can be transformed into a variety of fuels usable with today's infrastructure.

The conversion of natural gas to hydrocarbons (Gas-To-Liquids route) is currently one of the most promising topics in the energy industry due to economic utilization of remote natural gas to environmentally clean fuels, specially chemicals and waxes.

International Status:-

The actual process consists of many reactions like steam gasification, hydrogasification, methane reforming and water gas shift reaction (1). Pressure – temperature conditions dictate the extent of each reaction that in turn decides the composition of product gas. The energy efficiency of solar coal gasification process is estimated at 46 – 50 % (2).

Piatkowski et al. (3) gave a detailed review on thermodynamics, kinetics and reactor technology for gasification of coal based feedstock. Similar to methane reforming and decomposition processes, the reactors used for coal gasification can be classified as directly and indirectly heated reactors. Directly heated reactors developed so far are vortex flow and fluidized bed reactors, while packed bed and entrained flow reactors have been popular for indirect heating.

Pilot scale demonstration on solar gasification of solid carbonaceous feedstock has been done in EU programs SYNPET and SOLSYN. The project SYNPET was based on solar gasification of coal to produce syngas. In this project, a 5 kW vortex flow reactor was developed tested for steam gasification of pet coke (4), pet coke water slurry (5) and petroleum vacuum residue (6).

The vortex flow technology was then up scaled to demonstrate steam gasification of coal slurry in a pilot 500 kW plant (7). The project SOLSYN aimed at solar upgrading of solid carbon feed to produce high quality syngas that will be used to substitute fossil fuels in cement kiln.

Packed bed reactors can easily handle heterogeneous feedstock with varying composition, particle size and reactivity. The issues with packed bed reactors are lower heat/mass transfer in the porous bed that limits the reaction rate and energy conversion efficiency. It also increases ash build-up and leads to slagging and sintering inside the reactor (8).

The research group in Japan is working on coal gasification in a fluidized bed reactor (9–11).

However it was found that for this reactor, the reaction zone was quite narrow and large temperature gradient existed between the light irradiated bed surface and inside bed. This heat transfer limitation of the bed was responsible for low performance of the solar fluidized bed reactor. To overcome this problem, the group has proposed the concept of an internally circulating fluidized bed reactor (12-14).

Gasification is considered as one of the best method for the conversion of biomass because of space consideration, flexibility of fuel used, reducing the volume of solid waste & recovery of energy (15).

To enable India to handle with the conventional and demanding state of a shortage of petroleum fuels for surface transport in the future, potential alternatives are examined and evaluated that can ensure adequate energy for the transport sector with acceptable environment implications. The possibility of large-scale hydrogen production from renewable resources holds promise for scalable achievement and sustainability in the future but this would require huge technological challenges to be overcome. (16)

This study describes the potential of this proposed fuel resource scenario for transport fuels and discusses the technological challenges that would have to be addressed for its large-scale implementation.

Summary and Conclusion:-

A solar thermal system consists of concentrating optical surfaces that focus the energy to a target. At this focal point, the original incident energy is concentrated to thousands of times its original intensity, allowing for very high temperatures to be achieved (> 1000 °C). By implementation of a cavity receiver, these high temperatures can be maintained very efficiently (17-18). Central receiver solar thermal systems are currently operating to produce electricity commercially in Spain, but the technology remains underdeveloped for application to chemical process systems (18). These researchers found that solar energy could be stored in the products with an efficiency (energy chemically stored divided by energy delivered) nearing 50%, but did not operate above 1200 K; at these temperatures, some higher hydrocarbons were formed (19).

One of the problem regarding production of syngas that they may contain some trace elements of impurities, which are removed through further processing and either recovered or redirected to the gasifier. Syngas is a primary source of sulfuric acid. If syngas contains a considerable quantity of nitrogen, the nitrogen must be separated to avoid production of nitric oxides, which are pollutants and contribute to acid rain production. Both carbon monoxide and nitrogen have similar boiling points so recovering pure carbon monoxide requires cryogenic processing, which is very difficult.

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