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A Literature Survey On Different Solar Thermo-Chemical Reactor

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Abstract— **In this survey paper discuss on different solar thermo-chemical reactor. In the current generation solar thermo-chemical reactor play an important role in the electricity generation. Solar radiation is an abundant energy source with high energy content, suitable for driving thermochemical processes with high efficiency. This survey work provides a comprehensive review of the field of solar thermochemistry, with focus on production of fuels and other chemical commodities. In the last decade there are many research work purposed in the different solar thermo-chemical reactor. Thermochemical storage (TCS) systems have emerged as a potential energy storage solution recently due to the technology's superior energy density and absence of energy leakage throughout the technology's storage duration. In this review paper discuss on the different solar thermo-chemical reactor. Also discuss the different solar thermo chemical reactor in different solar thermo-chemical reactor .**

Keywords— Fischer-Tropsch synthesis (FT),computational fluid dynamics (CFD),local thermal non-equilibrium model (LTNE), Concentrated Solar Thermal (CST), etc ….

I. INTRODUCTION

From the studies of Gibbs and Carnot, two famous 19th-century scientists they founded the science of thermodynamics which seems to be the study of how energy can be transferred, for e.g., chemical energy obtained from solar energy, from one phase to another. Thermodynamics shows us, in quite simplistic words, that at higher temperature we transmit energy of solar to our process, more innovative we could be about what gets out like an end product. For instance, when we use sunlight in a traditional flat-plate solar collector, we can produce hot water which could be used to take baths or provide heat for space. While this kind of system will make much sense for some local conditions, this will not allow transportation to Japan of the solar energy produced in Australia. Although at very high temperature if we deliver solar energy to a chemical reactor, we increase the possibility for such a feat: solar energy produced in Australia will heat houses, provide power and can be used for many more**[11]**.

Decarbonisation of a transportation sector is a preventative measure against global warming. While a suitable alternative is electrification of cars which is thought to get the ability to improve the internal combustion engine, for air transport, analyses show that long-range transport is quite dependent on renewable resources too in the future because specific energy of its batteries is constrained. To get the pushy goals predefined by the aviation industry the uses of alternative fuels is thus imperative. Various options occur, like the electrochemical mechanism that integrates solar energy with electrolysis, or the photochemical mechanism that generates hydrogen using biomass or synthetic leaves**[12]**. By the use of complete solar radiation the thermo-chemical fuel offers high conversion efficiencies and it has recorded major performance advances in the past decades. The mechanism transforms CO2 and water into CO and H2 (syngas) utilizing concentrated sun's radiation as a fount of heat through a redox cycle controlled at high temperature, metal oxide is a substance that decreases partial pressure at low oxygen and high temperature, and oxidizes at lower temperatures with water and carbon di oxide. The produced syngas then converted attentively liquid hydrocarbons in the Fischer-Tropsch synthesis (FT), whereas a low-temperature synthesis gives longer- chained hydrocarbons, which then converted into chains of crave length in the jet fuel range by hydro- cracking and distillation. Benefit of solar thermo-chemical process is that the hydrogen and carbon mono oxide feed streams could be generated in independent reactors and thus easily taken to the needed around two in the FT reactor ratio of H2 / CO**[13]**.

Solar Researchers start focusing the diluted sun rays with the help of parabolic mirrors over a limited region and then grab a certain radioactive energy through the help of appropriate receivers, researchers would be able to receive heat at high temperatures to drive a chemical reaction and produce a reusable and moveable fuel. What type of fuel it uses is completely irrelevant since the theoretical maximum performance of such a mechanism is limited by the capacity of Carnot an analogue thermal engine.With the sun's surface serving as a 5800 K thermal reservoir as well as the planet serving as a thermal sink, it really is theoretically possible to convert 95 percent of renewable radiation into convert the chemical energy of fuels. When technology reaches this limitation, it's really the recipient's responsibility to develop but also develop the technologies**[14-16]**

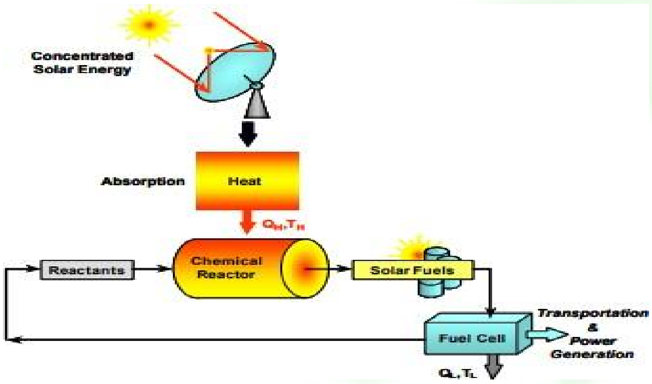

Fig. 1.Working of the Solar Thermo-Chemical Reactor

This article develops some of the underlying science and describes some of the latest technological developments for achieving this goal. The reader is exposed to the concepts of solar power concentration as well as the solar thermo chemical conversion thermodynamics.State of the art reactors are described with the most promising solar thermo chemical processes**[17]**.

II LITERATURE SURVEY

Zhang et al., 2018 - In this research work explains that thermal transfer and fluid flow characteristics have important impacts on the performance of hydrogen output as a primary technological parameter for porous media solar thermo-chemical reactor. The implementation of computational fluid dynamics (CFD) could solve these problems more effectively and at a lower cost. Additionally, the option of various models of thermal transport may cause results to vary. This researchers employed their FLUENT software to look at thermal convection flow conditions of a photovanden ersal heat transfer reactor, utilising porous materials at high temps.The findings suggest that local thermal non-equilibrium model (LTNE) and radiative transfer model have been shown to be invaluable for the thermal efficiency study of a thermo-chemical reaction system with high working temperatures. In comparison, Wu model of momentum source is best suited for simulating energy, while Wu model and Vafai model of heat transfer display no variation in temperature distribution**[01]**.

Falter and Pitz-Paal, 2018 - Explained in his paper that the solar thermo-chemical fuel processing pathway is being explored as an appealing alternative for transport sector decarbonisation. Usage of cerium as a reactive material and the new published literature data on inert gases demand and energy need for the vacuum pumping, Analyzes the energy output of the thermo-chemical reactor for vacuum pumping and gas mixture sweeping, and describes the process parameters needed to achieve high efficiency.Theoretically, it is observed that now the energy losses could be used to meet the need for electricity and low temperature heat, as well as heating the reactants to the oxidation temperature, Improving the quality of the route from 5.3% to 8.6%. Therefore, the heat recovery from the single process steps in the fuel production route has tremendous potential to increase process efficiency and considerably improve environmental and strategic results. Similarly, waste heat can be use to partly relieve the possibly strict operating conditions of highly powerful thermochemical reactors, which may have substantial reactor design consequences. **[02]**.

Huang et al., 2018 - Introduces a heavily biased and robust iron-based La0.6Sr0.4Fe0.8Al0.2O3-δ oxygen carrier for syngas processing via a thermochemical process powered by solar energy. It is observed that during redox cycling a complex structural transition occurs between the perovskite layer and a core – shell composite of Fe0@oxides. This core – shell intermediate is either regenerated in oxygen or more specifically in oxidant Pure water – Carbon dioxide with parallel production of another source of syngas to the initial perovskite structure. Doping with aluminium oxides decreases the ground oxygen content by reducing free electrons in the perovskite matrix, while preventing overoxidation of methan **[03]**.

Zsembinszki et al., 2018 - Examined that in order to compile a list of the most advanced reactors available in the literature that are used for solid gas reactions or thermal degradation mechanisms at temperatures of around 1000 C, but which can also be used for thermo-chemical energy storage in concentrated solar energy plants, specifically for solar power tower innovation.. Direct and indirect mechanisms can be applied, and the most studied are direct and closed mechanisms. The most widely used configuration by direct and closed systems is the stacked bed reactor, with the most frequent alternative being the fixed bed reactor. Out of all of the reactors studied, nearly 70% are used for solid-gas chemical reactions. Some data are available regarding solar efficiency in most of the processes, and the available information indicates relatively low values. While fluoridation processors provide greater chemical reaction efficiency than the adjusted as well as rotational options, the flow regime is particularly efficient for chemical reactions with dense gases **[04].**

Kodama et al., 2017 - It was proposed that solar thermal energy for the generation of high temperature fuel may greatly decrease our present economy's reliance on fossil fuels. Over the last two decades, remarkable progress has been made in the development of solar-driven thermo-chemical reactors for hydrogen and syngas production, as they are promising transport energy carriers, domestic and industrial applications**[05].**

Guene Lougou et al., 2017a - The total thermal performance of the solar thermo-chemical reactor for syngas generation was studied in his study. Prior to the introduction of the modern P1 design, the reactor's thermal performance was measured using P1 radiation. It used to be determined that the temperature distribution resulted in the incident radiation depth distribution during the reactor internal cavity. However, the greater temperature used to be attributed to a awesome absorption of incident radiation heat flux intensity. A enormous drop in temperature was once determined round the aperture location and sharply reduced with an amplify in the incident radiation depth from reactor inlet. The reactor at the beginning heating area used to be expanded with an extend in the reactor running temperature from a thousand K to 1600 K. It used to be found that greater the warmness flux was once utilized to the reactor, extra the reactor used to be heating up. The on the spot temperature distribution internal the reactor confirmed the rise in the temperature used to be brought on through the impact of radiation heat transfer. The service fuel go with the flow inlet velocity and the drop in the running stress have significantly affected the reactors thermal performance. High and extra uniform temperature distribution inner the reactor was once received via higher controlling of the reactor running conditions **[06]**.

Rao and Dey, 2017 -discussed that Solar photochemical potential of splitting water (artificial photosynthesis) to generate hydrogen is rising as a workable process. The photo voltaic thermo-chemical route additionally guarantees to be an attractive capability of accomplishing this objective. These encompass the low-temperature multistep system as nicely as the high- temperature two-step process.A multistep approach is notable, relying on ->2 temperatures are available for the Mn(II)/Mn(III) oxide machine: 700 °C and 750 °C. The two-step technique has been finished at 1,300°C/900°C by way of the usage of yttrium-based uncommon earth manganites.This may be done by reducing the high heat process to an isothermal technique. Thermodynamics and kinetics of water splitting are mostly managed by using the inherent redox property of the materials. Additionally, under the high-temperature temperatures of H2O splitting, CO2 may be degraded to CO, which can be used to produce the industrially required syngas (CO+H2) **[07].**

Falter and Pitz-Paal, 2017 - According to the authors, heat recovery from the stationary surface is a potential method for improving the cycle efficiency in non-stoichiometric redox processes that generate CO and H2 from Oxygen and h2o.In solar thermo-chemical reactor principles several various approaches to heat recovery and the gas separation have recently been proposed. To describe many possible degrees of freedom in the reactor design, a generic reactor model is described for two-step redox reactions of solid pieces of reactant moving in counter flow between reduction and oxidation chamber. The reactive substance is expected to be porous ceria, where heat recovery from the solid phase is accomplished by transferring heat from radiation between reduced and oxidised materials going in opposite directions. A separate wall avoids the passage of gas and provides structural protection. The temperature distribution by diffusion at the porous material is based on approximation of the Rosseland diffusion and the three resistor process by conduction. The model can be tailored to a broad variety of principles about the reactor**[08].**

Villafán-Vidales et al., 2017 - Said in his paper that Hydrogen is an exciting means of transport, household, and industrial energy carrier. In today's chemical sector, hydrogen is essentially the only raw material used, but its demand is projected to soar owing to new markets. As a result, a focus on hydrogen generation using sustainable methods is important. This research provides a description of the different thermo-chemical processes aided by CSP for the production of hydrogen and syngas. Some relevant prototypes of solar proven reactor are characterised for each process. Another aspect of thermo-chemical process study is research on solar furnaces. Furthermore, data on hydrogen and syngas generation in solar tower setups is described. Finally the current challenges of the technology and the process for its future commercialization are also analysed**[09].**

Xing et al., 2017 - Also told that Hydrogen energy can help us in solving the problem of greenhouse gases emissions which results in reduced global warming and stress on the fossil fuel supply and price, provided that hydrogen is produced by clean processes involving renewable energy. Creating solar hydrogen via a 2 thermo-chemical cycle is a tempting method. An effort is made throughout this study to provide an overview of the use of redox couples in the development of solar thermochemical hydrogen as well as reactor design technologies and general assessment. In the last decade, several new reactors have been developed for use with various redox pairs**[10].**

III. TYPES OF SOLAR ENERGY

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Solar energy is a popular choice for a lot of consumers, businesses and organisations that are seeking to generate greener energy as well as save on their energy bills. Indeed, most of us are familiar with the look of photovoltaic panels and rightly perceive solar energy as energy which is generated by the sun rays that reach photovoltaic panels.

However, there is much more to solar energy both in terms of set-up as well as the types of solar energy. This article will shed some light on the different types of solar energy so that our readers can make better informed choices when choosing the kind of solar energy that they would like to see installed in their homes**[18-20]**.

A. Photovoltaic systems

One of the most common ways to use solar power is to use photovoltaic systems or as they are also known solar cell systems, which produce electricity directly from sunlight.The basic principle behind this technology is similar to what we see in clock or calculators that are powered by the sun!

The semiconductor materials used in these solar energy systems absorb sunlight which creates a reaction that generates electricity – to be exact, the solar energy knocks the electrons loose from their atoms which makes them flow through the semiconductor material and produce energy.Today, solar panel technology can absorb and convert into energy most of the visible light spectrum and about half of the ultraviolet and infrared light spectrum .

Solar cells are typically combined into modules that hold about 40 cells and as a whole can measure up to several metres on the side. Because of their adjustable size and share, these flat-plate photovoltaic arrays can be mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight over the course of a day**[21]**.

B. Thin film solar cells

What is more, this type of technology can also be run with thin film solar cells which use layers of semiconductor materials only a few micrometres thick. This has made it possible for solar cells to double as rooftop shingles, roof tiles, building facades, or the glazing for skylights or atria maximising use of the available space from where sunlight would be captured.

C. Solar water heating systems

A second type of solar energy is solar hot water which as the name suggests involves the heating up of water using the sun's heat. The idea behind this comes straight from nature: the shallow water of a lake or the water on the shallow end of a beach is usually warmer compared to deeper water. This is because the sunlight can heat the bottom of the lake or seashore in the shallow areas, which in turn, heats the water.So, a system has been developed to imitate this: solar water heating systems for buildings are made up of two parts, the solar collector and a storage tank**[22]**.

D. Solar power plants

A third way we can harness the sun's power for energy is solar electricity; this is usually used in industrial applications. As most of us know, most power plants use non-renewable fossil fuels to boil water.The steam from the boiling water makes a large turbine rotate which in turn activates the generator to produce electricity. This way of generating electricity is bad for both the environment and our health given the emission of greenhouse gases and air pollutants from the burning of fossil fuels. In this below on figure 3**[23]**.

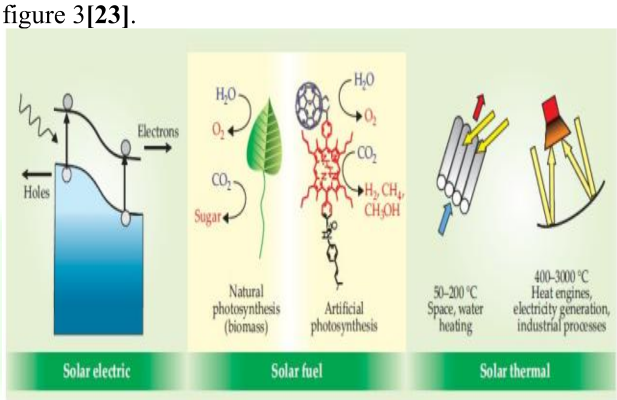

Fig. 2. Areas of solar energy (Bin, 2002)

IV. Solar Thermal Energy

From personal experience, we know that when something sits in the sunlight for a while it is warm to the touch. If you have ever stepped out barefoot on the sidewalk on a summer day then you have experienced the thermal power of the sun. Simply put, solar thermal energy is the area of solar energy that uses the heating effect of sunlight to heat something else, for example water which can then be used in traditional power plants to generate electricity.(Kumar, Hasanuzzaman and Rahim, 2019)

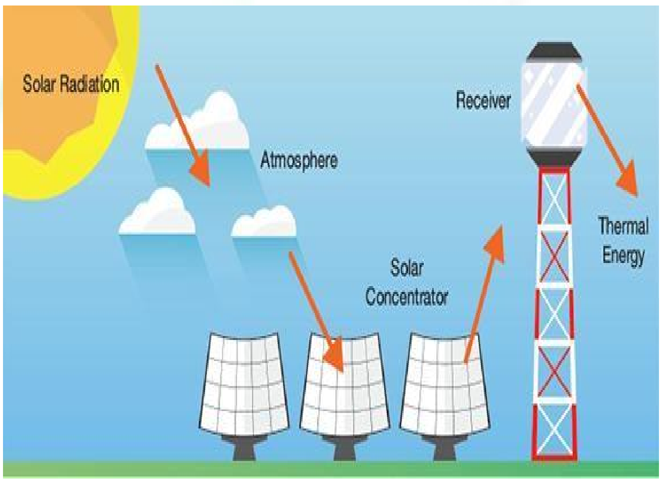

Fig. 3 Solar Thermal Energy, [24]

Solar thermal collectors are classified by the United States Energy Information Administration as low-, medium-, or high-temperature collectors. Low-temperature collectors are generally unglazed and used to heat swimming pools or to heat ventilation air. Medium-temperature collectors are also usually flat plates but are used for heating water or air for residential and commercial use.High-temperature collectors concentrate sunlight using mirrors or lenses and are generally used for fulfilling heat requirements up to 300 deg C / 20 bar pressure in industries, and for electric power production. Two categories include Concentrated Solar Thermal (CST) for fulfilling heat requirements in industries, and Concentrated Solar Power (CSP) when the heat collected is used for electric power generation. CST and CSP are not replaceable in terms of application.

The largest facilities are located in the American Mojave Desert of California and Nevada. These plants employ a variety of different technologies. The largest examples include, Ivanpah Solar Power Facility (377 MW), Solar Energy Generating Systems installation (354 MW), and Crescent Dunes (110 MW). Spain is the other major developer of solar thermal power plant. The largest examples include, Solnova Solar Power Station (150 MW), the Andasol solar power station (150 MW), and Extresol Solar Power Station (100 MW)**[25]**.

V.CONCLUSIONS

In this survey paper discuss on Different Solar Thermo-Chemical Reactor.The important outcomes of this paper are shown in the section of comparative analysis. In this survey paper observe that the Different Solar Thermo-Chemical Reactor Thermodynamics shows us, in quite simplistic words, that at higher temperature we transmit solar energy to our process, more innovative we could be about what gets out like an end product. In future design a better a Solar Thermo-Chemical Reactor design. That can improve all these problems in this communication area. In future try to design area optimization of Solar Thermo-Chemical Reactor design that can Solar Thermo-Chemical Reactor .

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