

Instrumentation & Control of Green Hydrogen Production Plant

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ABSTRACT

This paper is based on the documentation in monitoring the process. Paper titled “Instrumentation and Control for Green Hydrogen Production Plant” is of plant in initial stage. Initial Stage of the production plant, storage of the process (Hydrogen) which will be raw process. Fluid Raw material DM with the capacity of 20 Tons/hr is then divided into four different lines but with the same operation and the process. Hydrogen and oxygen will be the final products from this process. By taking Process Flow Diagram PFD as a reference, the Piping and Instrumentation Diagram P&ID is prepared and Control Philosophy for the hydrogen Production plant is proposed for implementation.

Keywords: Green Hydrogen, Control and Instrumentation, P&ID, Electrolysis, Alarm and Safety.

INTRODUCTION

History of Hydrogen production is long back in the early 16th century produced by the reaction of acids on metals. and later scientists and engineers made progress with hydrogen production, developments and its uses.

The most abundant chemical in the universe is Hydrogen constituting roughly 75% of all normal matter. We can produce hydrogen by several ways as given in Fig 1.

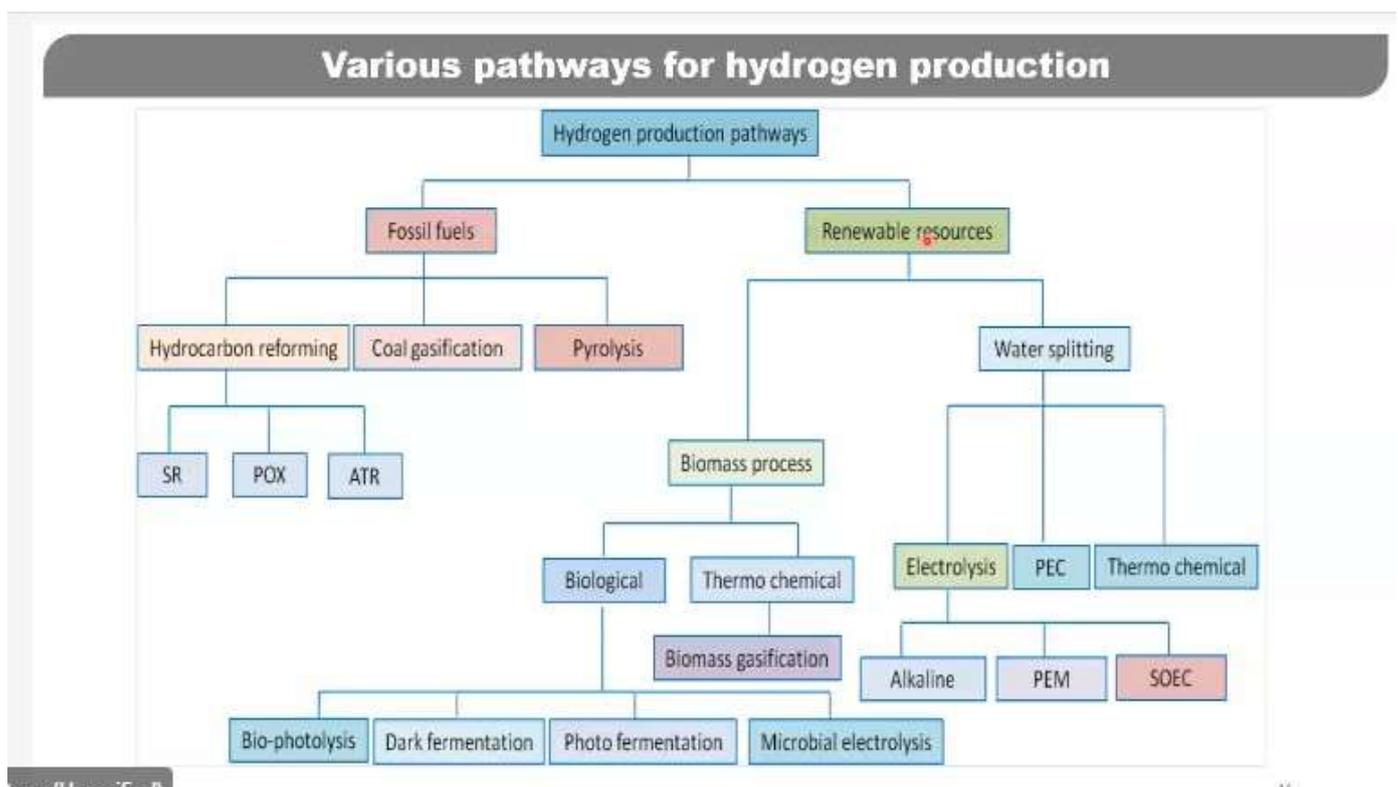


Fig 1

The most efficient way would be to use renewable energy sources to generate hydrogen. Here we will mainly focus on 'Green Hydrogen'. Fig 2. As is name Green, the methods that are used to produce hydrogen are environmentally safe. Green Hydrogen is defined as H₂ gas produced by electrolysis i.e. splitting water into hydrogen and oxygen using solar renewable electricity.

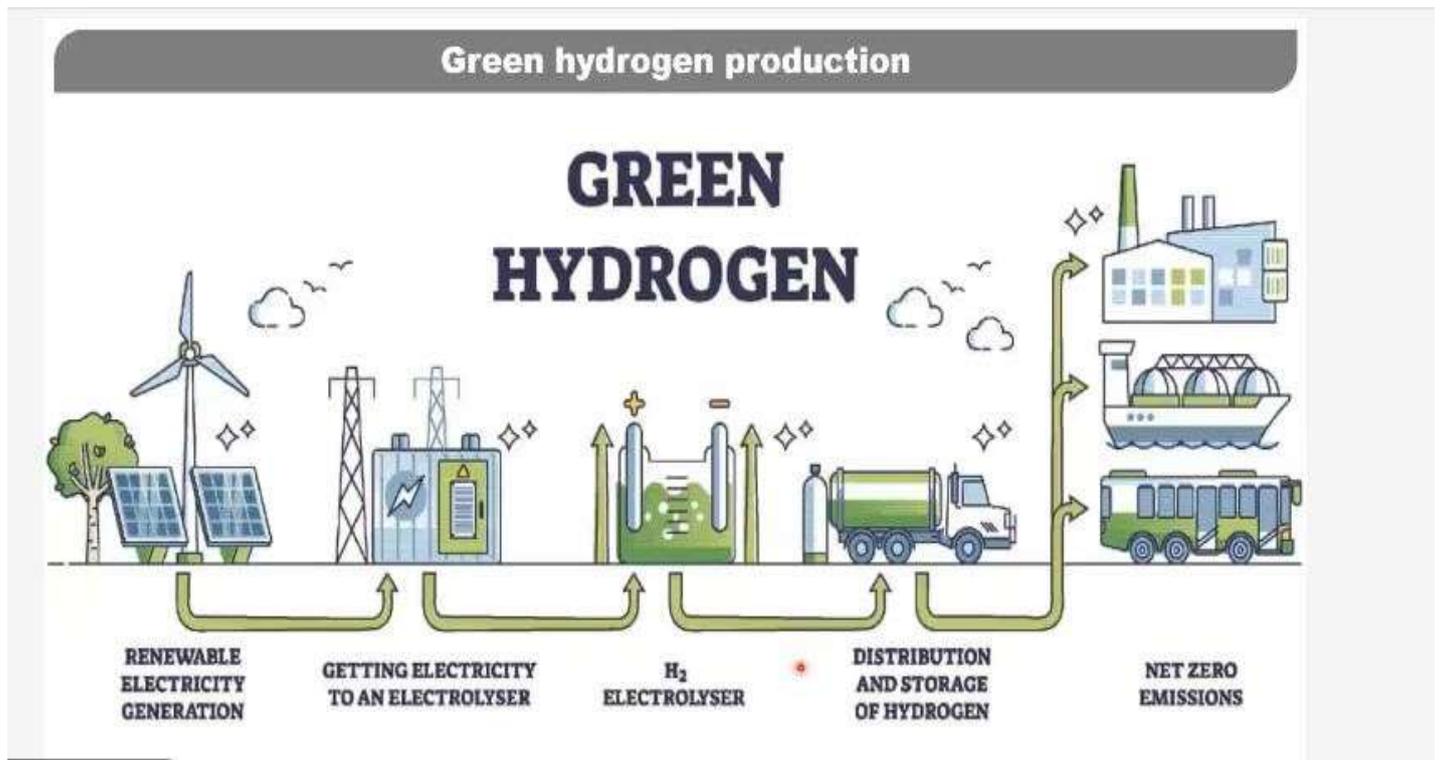


Fig 2

The paper titled “**Instrumentation and Control for Green Hydrogen Production Plant**” is based on the project which is in its initial phase. The production of the process is separated into two different quantities 35 Mega pascal and 70 Mega pascal.

And it will be stored in two different systems for various uses, like a dispenser system, a storage system and transportation. Here we developed the Control Philosophy for Hydrogen Production Plant.

There are a number of control loops in the production plant such as equipment, instruments and other systems for operation of process. The document Control Philosophy is the document which is developed to give a description of these loops and system. And with the reference of PFD, Piping & Instrumentation Diagram P&ID is created for the Initial stage of the Plant, which specifies Instruments, Sensors, Measuring Elements, etc. The software used for making this document delivery is Auto CAD, MS Word.

APPARATUS

DM Water input supply: A Demineralised water DM is water that has been purified of its mineral ions and impurities through a process called ion-exchange.

DM water is important for the production of hydrogen gas through electrolysis.

The mineral ions in water can cause problems by interfering with the process or contaminating the final product.

Electrolysis Process: It is the process of separation of water, using electricity, into its constituent parts, hydrogen and oxygen. The process of electrolysis takes place in an electrolytic cell, called as Electrolyzer. Electrolyzer contains two electrodes Anode and Cathode separated by an Electrolyte.

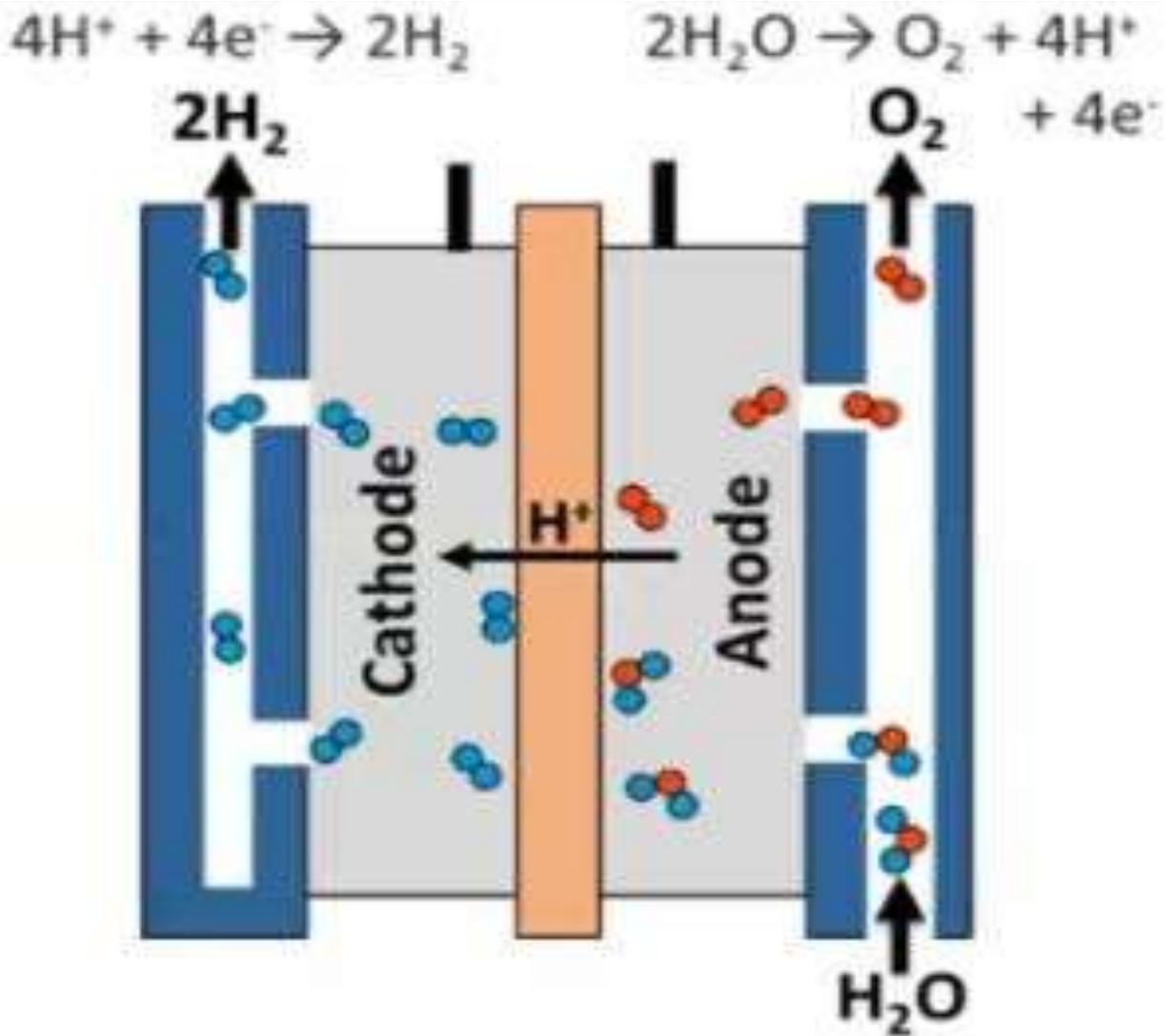


Fig 3

At the anode, water molecules are oxidized, releasing oxygen gas and positively charged hydrogen ions (H^+). These positively charged ions move towards the negatively charged cathode. At the cathode, the hydrogen ions are reduced to form hydrogen gas (H_2) and electrons (e^-).

The electrons flow through an external circuit to the anode, where they combine with oxygen atoms to form oxygen gas.

The electrolysis process can be given as follows:

$2\text{H}_2\text{O}(\text{liquid}) + \text{energy} \rightarrow 2\text{H}_2(\text{gas}) + \text{O}_2(\text{gas})$ The efficiency of the electrolysis process depends on several factors, including the voltage applied, the size and design of the electrolytic cell, the concentration of the electrolyte solution, and the purity of the water used.

- **Compressor:** It is used to increase the pressure of a gas or fluid by reducing its volume. Hydrogen gas is typically produced at low pressure, and it needs to be compressed to a higher pressure for use in various applications.
- **Heat Exchange unit:** It involves the transfer of heat energy from one fluid to another through a thermally conductive surface or barrier. In hydrogen production plants it is required for heat recovery and to cool the hydrogen gas.
- **Moisture Trap:** A moisture trap is a device used to remove moisture or water vapor from a gas or air stream.
- **Dryer:** It is an essential component of a hydrogen production plant because it is used to remove moisture



from the feed stock or process gas.

Instrumentation And Control

DM water is important for the production of hydrogen gas through electrolysis. Fig3. Electrolysis is a process where an electric current is passed through water to split it into hydrogen and oxygen. [2] During this process, the mineral ions in water can cause problems by interfering with the process or contaminating the final product. When DM water is used for electrolysis, it ensures that the water is free of minerals and other impurities that cannot interfere with the process. This helps to ensure the efficiency of the electrolysis process and to produce high-quality hydrogen gas that is free of impurities. The Closed loop operation is suitable for the water tank process.

Feedback signal process control to be compared with the reference input, thereby providing controlled action. The DM water storage tank is used to store water which will be used in the H₂ plant for the electrolysis process. For level measurement level switch – Vibrating Fork Switch is used as level element. (LE). This LE sends an electronic signal to an indicator and alarms LAH and LAL, according to the alarm operator, will get to know the level of the storage tank. For the final control element, the ball valve is suitable.

There are two main equipment in hydrogen plant 1. The hydrogen generator and 2. The power supply. The hydrogen generator consists of mechanical equipment and piping systems supporting the electrolysis process. The power supply consists of equipment to convert AC power input into DC power in the electrolysis process. The power supply at the installation is separate from the hydrogen generator. In the electrolysis process, two products will be produced, namely hydrogen (H₂) and oxygen (O₂). Here we are mainly focusing on hydrogen and its Control Process. The hydrogen we receive from the process will be stored in a hydrogen storage tank. This hydrogen gas will not be in 100% pure form. To get into a pure and desirable state, further processing and control is needed. For storage monitoring, level and pressure parameters are integrated.

Water vapor can be problematic in a hydrogen production plant because it can cause corrosion of the equipment, reduce the efficiency of the process, and lower the quality of the hydrogen gas. A moisture trap is used to remove water vapor from the hydrogen gas stream before it is compressed and stored. The gas which enters the moisture trap removes water and other impurities from hydrogen. The purified gas is discharged from the moisture trap to the moisture separator.

Compression allows a low-pressure well to produce higher volumes of natural gas, in some instances, well production may be entirely dependent upon gas compression. Multi-stage compressors can regulate air temperature. Because the cool air as it passes between each chamber, the output air has a lower temperature.

As gas is compressed, the temperature of gas increases. To maintain the temperature, this compressed gas will be passed through shell and tube heat exchanges. This heat exchanger is used to heat up to process fluid at desired outlet temperature. Therefore, action must be taken to correct any deviation so as to maintain the outlet process temperature at its desired value. Here, we have to maintain the range of the temperature at 25°C.

For temperature measurement, **RTD** can be used as TE. RTD has a temperature measurement range of -200°C to 850°C. It is a 4wire Pt100 element type. It gives an output of 4-20mA. It possesses high accuracy of measurement, it responds quickly, it gives stable and accurate. It possesses high accuracy of measurement, it responds quickly, it gives stable and accurate performance over many years. Temperature compensation is not required.

Based on them are various alarms and Indicator

Fig 4 is the Designed. It is the Control Philosophy of plant.

The power supply consists of equipment to convert AC power input into DC power in the electrolysis process.

After Heat Exchanger, the Hydrogen Gas will pass through dryer. In the drying process, all the leftover moisture will get cancelled out and thus this passes to the hydrogen storage. A FlowTransmitter and a FI Indicator along

with alarms FAH and FAL are provided to measure and indicate flow.

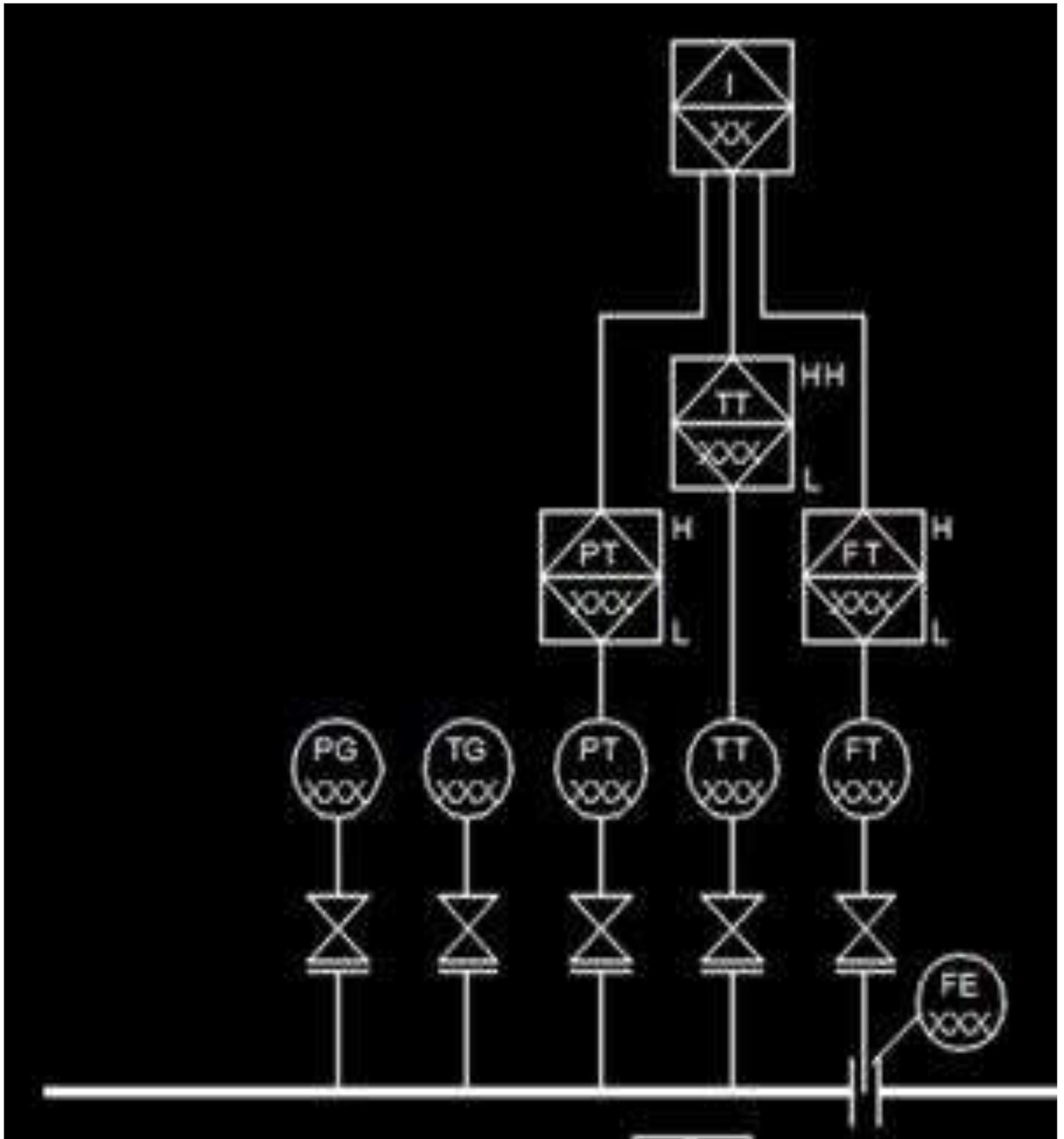


Fig 5

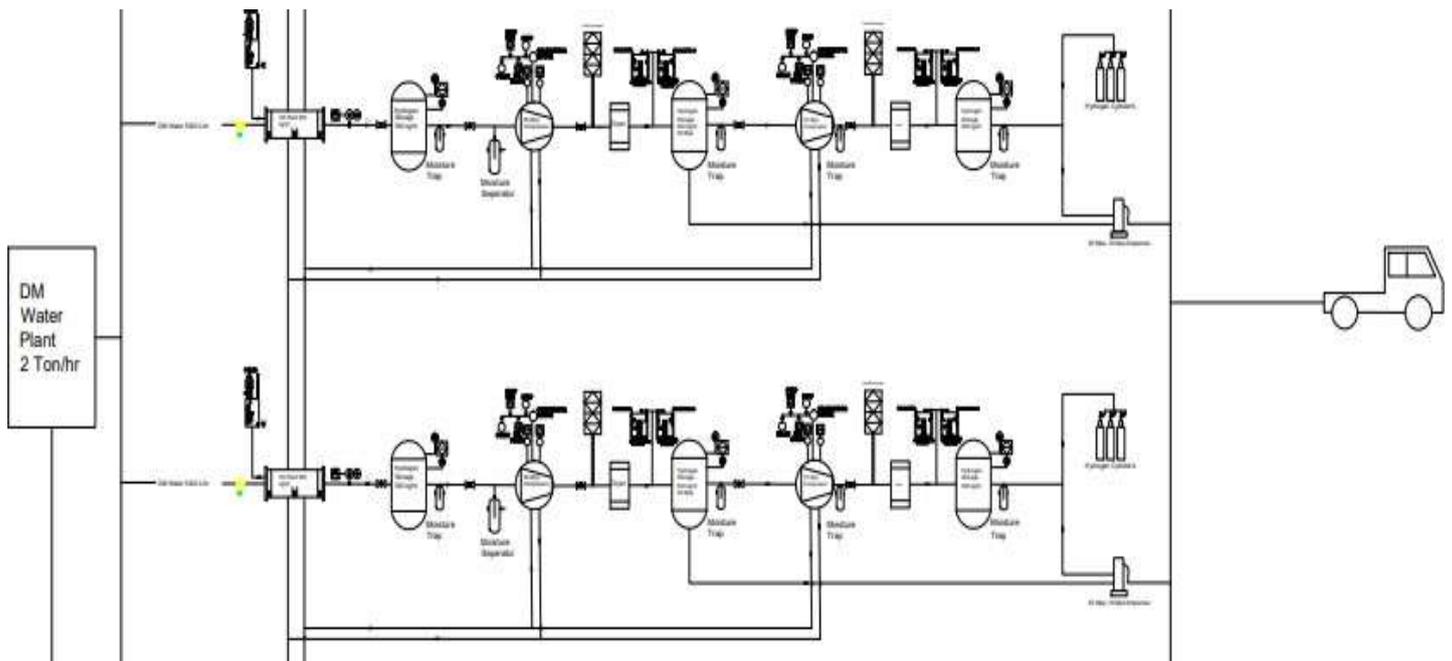
There are Level elements, Flow element, Temperature element, pressure element. Fig 5. [1]

Control Documentation With Flow control, we need to monitor and control the pressure parameters as well. Temperature compensation is not required.

Control systems and instruments are located near the generator. The control panel shows the process conditions and information data for the efficiency of the operating system.

Control Philosophy Of Hydrogen Gas Process

Process Flow Diagram Proprietor- UTPNN Green Tech Pvt. Ltd. Fig 4 as shown below



Abbreviations and Acronyms are used in P and I Diagram DM - Demineralized Water, LE- Level Element TE- Temperature Element, LAH- Level Alarm High LAL- Level Alarm Low, FT- Flow Transmitter PT- Pressure Transmitter, TT- Temperature Transmitter FAL - Flow Alarm Low, FAH - Flow Alarm High

FI - Flow Indicator, FE – Flow Element Mpa- Mega Pascal

RTD- Resistance Temperature Detector

Hydrogen Hazards and safety

Hydrogen is a colorless, odorless, tasteless gas that is lighter than air. Hydrogen is extremely flammable and can be ignited by the cylinder valve being opened to air and by heat, sparks and static electricity. Constantly contact with hydrogen can cause acute health effects, chronic health effects. Hydrogen is lighter than the air and can accumulate in upper sections of enclosed spaces. Hydrogen may form an ignitable vapor/air mixture in closed tanks or containers.

Hydrogen Leak Detection

If a hydrogen leak does occur, it is important to follow proper safety procedures, such as evacuating the area, ventilating the space, and avoiding any sources of ignition. It is also important to repair the source of the leak as soon as possible to prevent further releases of hydrogen gas. Two technologies suitable for detecting hydrogen: pellistor sensors and electrochemical sensors. Pellistor, or catalytic bead, sensors rely on the use of a catalyst that causes flammable gas within the sensor to ignite at a much lower temperature than usual.

When combustion occurs, heat is produced in proportion to the amount of flammable gas present. The concentration of flammable gases can then be derived from this measurement and expressed as a percentage of the lower explosive limit (%LEL). Pellistor sensors are typically used as a general “catch-all” technology for flammable gas detection. Pellistors respond to any flammable gas, measuring 0-100% LEL.

Since a 4% concentration of hydrogen is explosive, this corresponds to 100% LEL. Thermal Conductivity Detectors, the temperature of the sensing element depends on the thermal conductivity of the gas flowing around it. Thermal conductivity leak detectors have cells that contain coils in bridge circuits.

Infrared absorption sensors These sensors use infrared light to detect the presence of hydrogen gas. They are

relatively accurate and can detect hydrogen at concentrations as low as 1% in air.

Thermography involves the detection of temperature differences by scanning in the IR region of the spectrum. Leaking valves and steam traps are easily located through the use of this technique.

Final Control Element

Final Control Elements are control valves which are an essential part of the process as they are part of the total control of the process and manipulation of the outcomes. Valves can be placed at the beginning and end of the pipeline to control the flow of hydrogen in and out of the pipeline. This can be useful for isolating the pipeline for literature for the best options for a particular pipeline and application.

Valve sensors are instruments used to indicate the position of a valve. For example, when installed on a shutoff valve like a ball valve, sensors such as limit switches are used to indicate whether the valve is fully opened or fully closed. Valve position sensor readouts can be displayed via lights, dials with hands or digital maintenance or emergencies, or for diverting the flow of hydrogen to another location. The specific placement of Ultrasonic (acoustic) gas leak detection technology functions through the constant monitoring of wide areas by advanced acoustic sensors specially tuned to process ultrasound emitted from pressurized gas leaks.

Future Scope

Zero emission-The only emission from a fuel cell vehicle using hydrogen is water steam. Hydrogen is thus a clean fuel for cars without emissions of pollutants and greenhouse gases that contribute to climate change. Fast Refuelling- Hydrogen charging stations are quite similar to the traditional filling stations. As hydrogen vehicles don't need to be plugged in to charge unlike battery powered electric cars - the process of refuelling is quick.

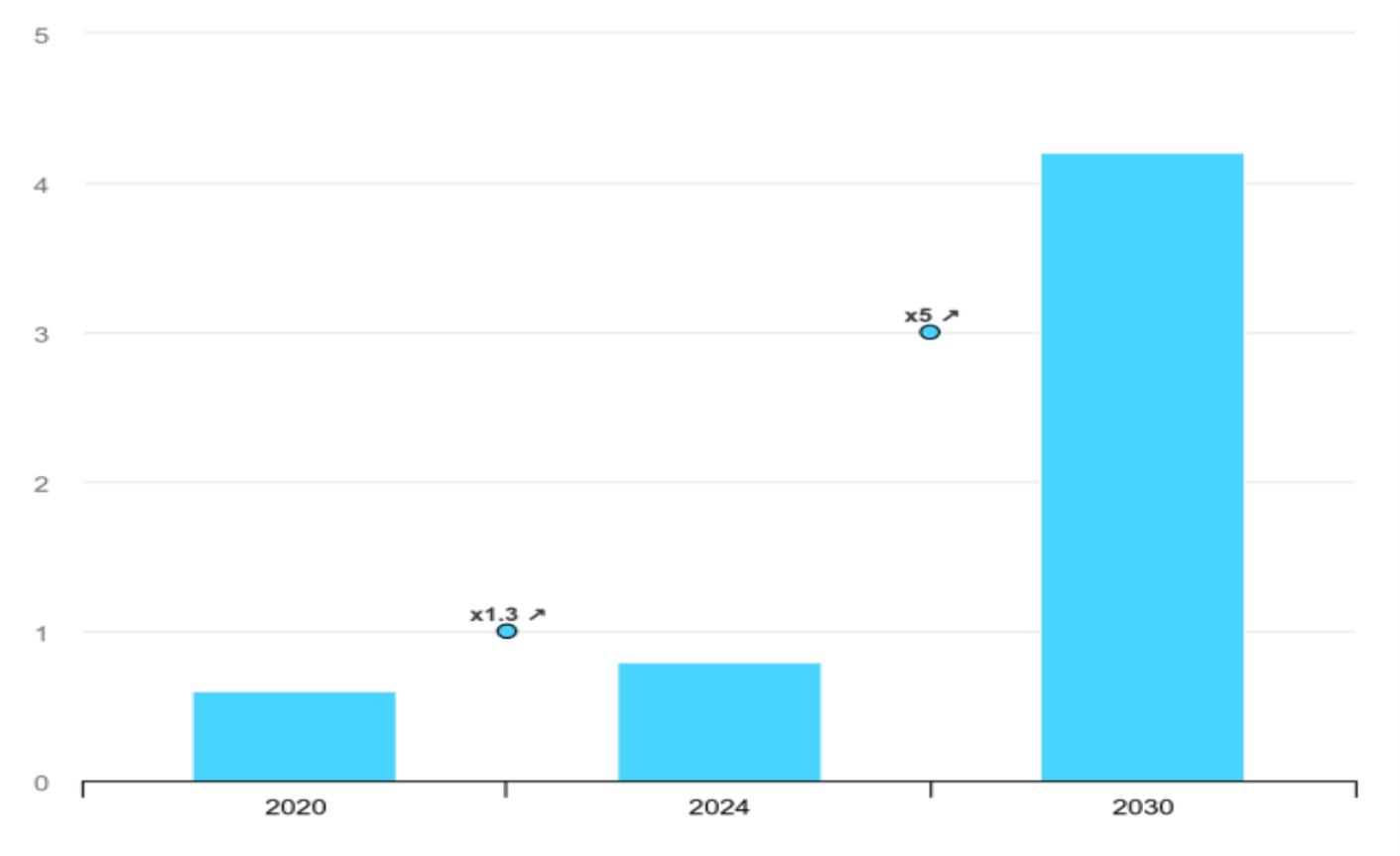


Fig 6

For now, global hydrogen consumption is still low, less than 2% of global energy. But according to the Hydrogen Council, this consumption could reach 25% by 2050. Shown in Fig 6. The Solar Impulse Label is granted to innovative solutions for hydrogen mobility that meet high standards of sustainability and profitability.

The prospects for the hydrogen economy are good. [7] It could play a major role in the energy transition since it

has a high energy efficiency, emits no pollutants locally and can contribute to massively reducing greenhouse gas emissions.



National Green Hydrogen Mission Outcome

- 5 MMT of Green Hydrogen Produced Annually by 2030.
- 6 lakh+ green jobs Created Across the Value Chain.
- ₹1 lakh crore reduction in fossil fuel imports.
- 50 MMT of greenhouse gas emissions avoided annually.

Sources: MNRE, Ministry of Ports, Shipping and Waterways

The infographic features a light blue background with a white wind turbine silhouette at the bottom right. A central photograph shows an industrial hydrogen production facility with several large blue storage tanks and piping. In the top right corner, there is a logo for 'pib' (Press Information Bureau) and a blue recycling symbol.

Fig7

MNRE has stated few outcomes. [6] Most important is usage of Hydrogen fuels will reduce 1 lack crore Fossil fuel imports.plant and paper based on the same, titled “**Instrumentation and Control for Green Hydrogen Production Plant**”.

In this aspect, we are eternally grateful to all those who have directly or indirectly helped.

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[1] <https://www.pib.gov.in>



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