HyTecHeat

HYbrid TEChnologies for sustainable steel reheating – HyTecHeat

HORIZON-CL4-2022-TWIN-TRANSITION-01-16, Modular and hybrid heating technologies in steel production (Clean Steel Partnership)
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Deliverable 4.1: Electrolyser installation
WP4: Laboratory tests of burner prototype and possible design improvements

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EXECUTIVE SUMMARY

The deliverable 4.1 was prepared as part of the European Commission Horizon 2022 funded project Hytecheat, "HYbrid TEChnologies for sustainable steel" (Grant Agreement-101092087-HyTecHeat). The aim of this report is to describe the main characteristics of the electrolyser and also the relative installation at Tenova premises. (activities refer to WP4). This document is a Confidential Deliverable for the partners of the Hytecheat project and the European Commission (EC).

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OVERVIEW OF THE DELIVERABLE

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1 LIST OF ABBREVIATIONS AND ACRONYMS

AWE – Alkaline Water Electrolysis
CA – Consortium Agreement
D – Deliverable
DoA – Description of Action
EC – European Commission
FP – Framework Programme
GA – General Assembly
H2020 – Horizon 2020 The EU Framework Programme for Research and Innovation
IPR – Intellectual Property Right
PC – Project Coordinator
SC – Steering Committee
WP – Work package
SAT – Site acceptance test

2 INTRODUCTION

Industrie De Nora S.p.A. (IDN), world leader in the production and supply of electrodes for electrochemical processes, has been involved for the development of a demo unit for the production of gaseous hydrogen by alkaline water electrolysis (AWE). The system is conceived as a turnkey containerized unit which includes the electrolyzer, electrolytic circuits, gas/liquid separators, instrument air and nitrogen generation systems, power supply (including transformer and rectifier), instrumentation and control system.

The hydrogen produced by the Dragonfly system is expected to feed steelmaking processes, (an hydrogen burner developed by Tenova), an energy-intensive and therefore environmentally highly impactful activity. The goal is to reduce this impact in the heat treatment and heating stages, which are still exclusively based on natural gas, by increasing the percentage of low-carbon hydrogen used in these processes in an increasingly virtuous hybridization of the two resources.

The plant is designed up to 220 Nm3/h of gaseous hydrogen with a required power of 1 MW (AC) and has been conceived to be placed inside a customized shelter with standard dimensions. The production is continuous up to 8000 hours/year.

3 DRAGONFLY® SYSTEM

The core of the process is the Hydrogen Production Unit, by using Alkaline Electrolysis technology. This type of electrolyzer utilizes a caustic solution (KOH 28-33% as an electrolyte, which promotes the hydrolysis reaction in the anodic and cathodic cells of the electrolyzer, producing gaseous O2 and H2 respectively. The electrolyzer is kept at constant temperature using a glycole/water cooling solution in a closed loop.

The make-up water for the process is imported from battery limit, fed to the Demi Water Production Unit and then sent to the H2/catholyte separator.

The plant needs air for the valve actuators and nitrogen for purging and pressurizing the cooling circuit. For this reason, an air compressor and an on-site nitrogen production system were provided.

The O2 produced in the electrolyzers is vented to atmosphere as by-product, while the H2 stream is post-treated in the Hydrogen Drying Unit and then sent to end users at battery limit.

The battery limits of the plant are the following:

- Demi Water Unit inlet connection (from Tap Water Network)
- Produced H2 outlet connection (to storage / users)
- Produced O2/H2 vent gas
- Liquid Blowdown outlet connection (to drains collection / sewer treatment)

As for the power supply, medium voltage at the battery limit is subsequently converted into low voltage through the transformers for auxiliaries and rectifier respectively; the rectifier feeds the electrolysis stack.

The power supply unit has been designed to allow the electrolyser to operate at high current density and ensures continuous hydrogen production.

A UPS system allows the system to keep the power for keeping safety conditions at shudown: current break, depressurization and flushing with nitrogen.

The entire system is equipped with a control system regulated by a PLC and a fire extinguishing system.

Both systems are connected and have an exchange of signals with the Tenova plant. The whole system is designed into four sections described below

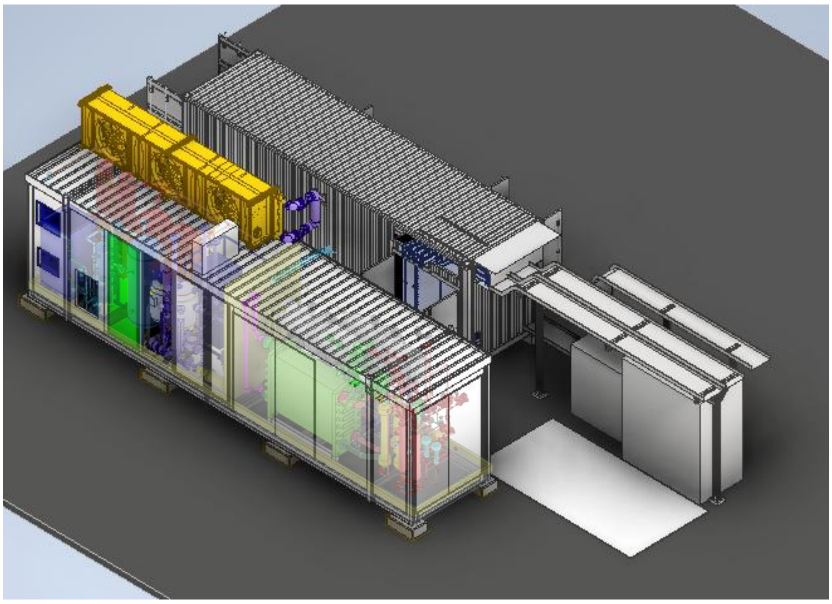

Figure 1 – Dragonfly installation

Section 1. Hydrogen/Oxygen production and electrolyte recirculation design

Caustic potash solution is fed in closed loop in the main process stream, it flows inside the electrolyzer where gaseous hydrogen (cathodic section) and oxygen (anodic section) are produced; the resulting biphasic mixture of potash solution is sent to hydrogen potash degasser for separation of phases.

Gaseous hydrogen is separated and sent to following dehydration, while oxygen is vented as by-product; caustic potash solution, once filtered, is partly recirculated to electrolyzer and partly pumped to the remix loop for potash concentration balancing purpose.

Heat generated in the electrolyzer due to Joule effect is dissipated by mean of a cooling circuit in a closed loop.

The electrolyzer is the core of the system and it composed by a stack of electrolytic cells in electrical series.

The continuous current (DC) required for the electrochemical reactions is supplied by a power rectifier (transformer) which converts the AC power generated by the grid into Low Voltage DC power for the electrolyzer and is electrically connected to it by power cables.

Section 2. Demi water package design

The overall balance of the two semi-reactions results in the production of hydrogen and oxygen at the expense of solution water that needs to be restored, thus a continuous demi water make up is provided to hydrogen potash degasser.

Demi water is continuously produced from tap water. The sizing of this package was carried out after water analysis and in order to minimize inorganic accumulation inside electrolyzer.

Section 3. Cooling water circuit design

Heat generated in the electrolyzer due to Joule effect is dissipated by mean of a cooling circuit.

Cooling water solution (Solution E-Glycol 30% / Demi Water 70% w/w) is circulated by means of a circulation pump: hot solution is sent to Air cooler for cooling and subsequently sent to Electrolyzer for heat extraction.

Hot solution is then returned at the Cooling solution circulation tank. The overall pressure of the circuit is kept fixed by nitrogen continuously flushed to the tank.

Section 4. Air compression package and Nitrogen production unit

Atmospheric air is filtered at compressor inlet, compressed to operating pressure and sent to air drying section (composed of duplex type prefilters, two 100% twin bed dryers, one operating, one in regeneration and duplex type after-filters). After being dried, air is stored at the operating pressure of 14 barg inside Compressed air reservoir vessel.

The air necessary to the instrumentation is reduced by mean of PCV up to 7 barg and sent to the plant.

A stream of compressed dried air is sent to nitrogen production columns (composed of two 100% twin bed molecular sieves, one operating, one in regeneration).

Produced nitrogen is filtered and stored in the outlet buffer vessel. This is necessary to the continuous pressurization of the cooling water circuit and for the purge at the starting and shutdown sequences.

4 COMPLETED SITE ACTIVITIES

Once the containers (process, electro-instrumental and transformers) were positioned on site on 25th September 2024, the preliminary work of interconnection between the containers and the laying of the cables began.

Preliminary operations on the process container:

The air cooler was initially installed on the process container and connected to the stack cooling circuit. Subsequently, the oxygen side vent and the three hydrogen side vents were connected. These operations were shifted depending on logistical reasons for transporting the container.

Preliminary operations on the electro-instrumental container:

The electro-instrumental container has been installed with the air conditioners necessary to maintain the cabin at a temperature suitable for the operation of the panels, PLCs and rectifiers.

Preliminary operations on the transformers container:

The transformers were laid on the concrete base and then the cover was placed and sealed to prevent them from coming into contact with water, as they are live equipment.

Operations of interconnections between containers:

Once the work had been carried out on the medium voltage current supplied by Tenova, the cables were laid and connected to the medium voltage switchboard and transformers.

5 NEXT STEPS

- Connection to medium voltage Tenova's substation
- SAT of Electrolyzer

Figure 2 - Process container at site

Figure 3 – Electro-instrumental + Transformers containers at site