Journal of Power Sources 293 (2015) 228–235

Contents lists available at ScienceDirect

Journal of Power Sources

journal homepage: www.elsevier.com/locate/jpowsour

Performance evaluation of a membraneless divergent electrode-flow-through (DEFT) alkaline electrolyser based on optimisation of electrolytic flow and electrode gap

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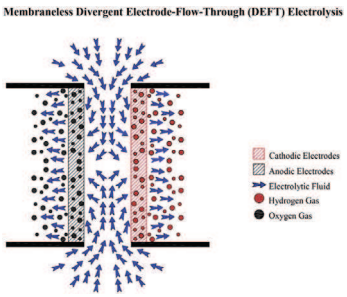
HIGHLIGHTS

- Membraneless alkaline electrolysis (MAE) reduces capital and maintenance costs.
- Gas separation by directing the flow of electrolyte in directly opposing directions.
- An HHV% efficiency of 75% below 2.00 VDC for the electrolyser stack alone.
- Hydrogen purity of 99.83% realised at electrolyte flow of 0.2 m s^{-1}.
- Current densities of 219.99 mA cm^{-2} (1.80 VDC) and 474.40 mA cm^{-2} (2.00 VDC).

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 14 December 2014
Received in revised form
14 May 2015
Accepted 18 May 2015
Available online 23 May 2015

Keywords:
Alkaline water electrolysis
Membraneless
Hydrogen production

ABSTRACT

A membraneless divergent electrode-flow-through (DEFT) alkaline electrolysis design and operating principle is investigated, which allows for the ohmic drop contribution and performance threshold limitations of a conventional membrane barrier to be overcome. Employing mesh electrodes of 30 mm diameter, operation of the electrolyser at an electrolytic flow velocity of 0.075–0.1 m s^{-1}, resulted in an optimal electrode gap of ~2.5 mm, while operating at greater velocities (>0.1–0.2 m s^{-1}) allows for the employment of a smaller optimal gap of ~0.8 mm. At an electrode gap of 2.5 mm and current densities of 3500 mA cm^{-2}, hydrogen purity of 99.83% has been recorded. With pure nickel electrodes current densities of 101.19 mA cm^{-2} (at 1.80 VDC) and 326.33 mA cm^{-2} (at 2 VDC) have been achieved, while the use of superior catalysts, namely, $RuO_2/IrO_2/TiO_2$ and Pt for the anode and cathode respectively, resulted in the current densities to increase to 219.99 mA cm^{-2} (at 1.8 VDC) and 474.40 mA cm^{-2} (at 2 VDC) at an electrode gap of 2.5 mm and a minimum flow velocity of 0.075 m s^{-1}. The test rig is capable of generating hydrogen at a rate of 63.6 L/hr at normal temperature and pressure (NTP). The production rate follows current density linearly at high overpotentials.

1. Introduction

Water electrolysis has proved to be an effective method of producing hydrogen employing renewable sources of energy [1].

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http://dx.doi.org/10.1016/j.jpowsour.2015.05.077
0378-7753/