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Countercurrent reactor design and flowsheet for iodine-sulfur thermochemical water splitting process

Jean Leybros [a,*], *Philippe Carles* [b], *Jean-Marc Borgard* [b]

[a] *CEA, DEN, Fuel Cycle Technology Department, F 30207 Bagnols-sur-Ceze, France*
[b] *CEA, DEN, Physical Chemistry Department, F 91191 Gif-sur-Yvette, France*

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ABSTRACT

A conceptual design is presented for the I/S process for the production of hydrogen using a high-temperature nuclear heat source to split water. The process includes a countercurrent reactor being developed by CEA within the framework of an international collaboration (I-NERI project) with DOE at General Atomics (San Diego, CA). A ProsimPlus™ model of the flowsheet indicates 600 kJ high-temperature heat and 69 kJ electric power are consumed per mole of H_2 product (with an assumed pressure of 120 bars). The net thermal efficiency would be 38% (HHV basis) if electric power is available at a conversion efficiency of 45%.

1. Introduction

Thermochemical water splitting cycles obtain hydrogen from water by means of several coupled thermal chemical reactions. They have attracted interest because of their capability to be coupled to a high-temperature nuclear or solar reactor [1]. The concept was originally proposed in the 1960s and since then thermochemical cycles have been proposed.

The iodine–sulfur process (IS process) is one of the cycles that has been studied most intensively. It was first described by General Atomics (GA) [2,3]. This cycle has also been considered by the Japan Atomic Energy Research Institute (JAERI) [4,5].

The French ‘‘Commissariat à l'Energie Atomique'' (CEA) has been involved in the IS process in a research program through theoretical and laboratory studies [6] and through the development of a laboratory scale hydrogen production loop (Fig. 1) which is currently performed within the framework of an international collaboration (I-NERI project with DOE) with two American partners: Sandia National Laboratories (SNL) and General Atomics [7]. A new countercurrent reactor concept has been proposed to implement the Bunsen reaction. As part of this work, CEA has also prepared a conceptual design of a process that uses the Bunsen reactor being developed and which is powered by a High-Temperature Gas-cooled Reactor (HTGR). A ProsimPlus™ flowsheet was prepared that incorporates the data and choices described later. The purpose of this article is to present the details of this flowsheet.

2. Background

2.1. The I/S process

The I/S process consists of three sections including the following chemical reactions:

Section I – Bunsen reaction

* *Corresponding author*. Fax: +33 4 66 79 60 31.
E-mail address: jean.leybros@cea.fr (J. Leybros).

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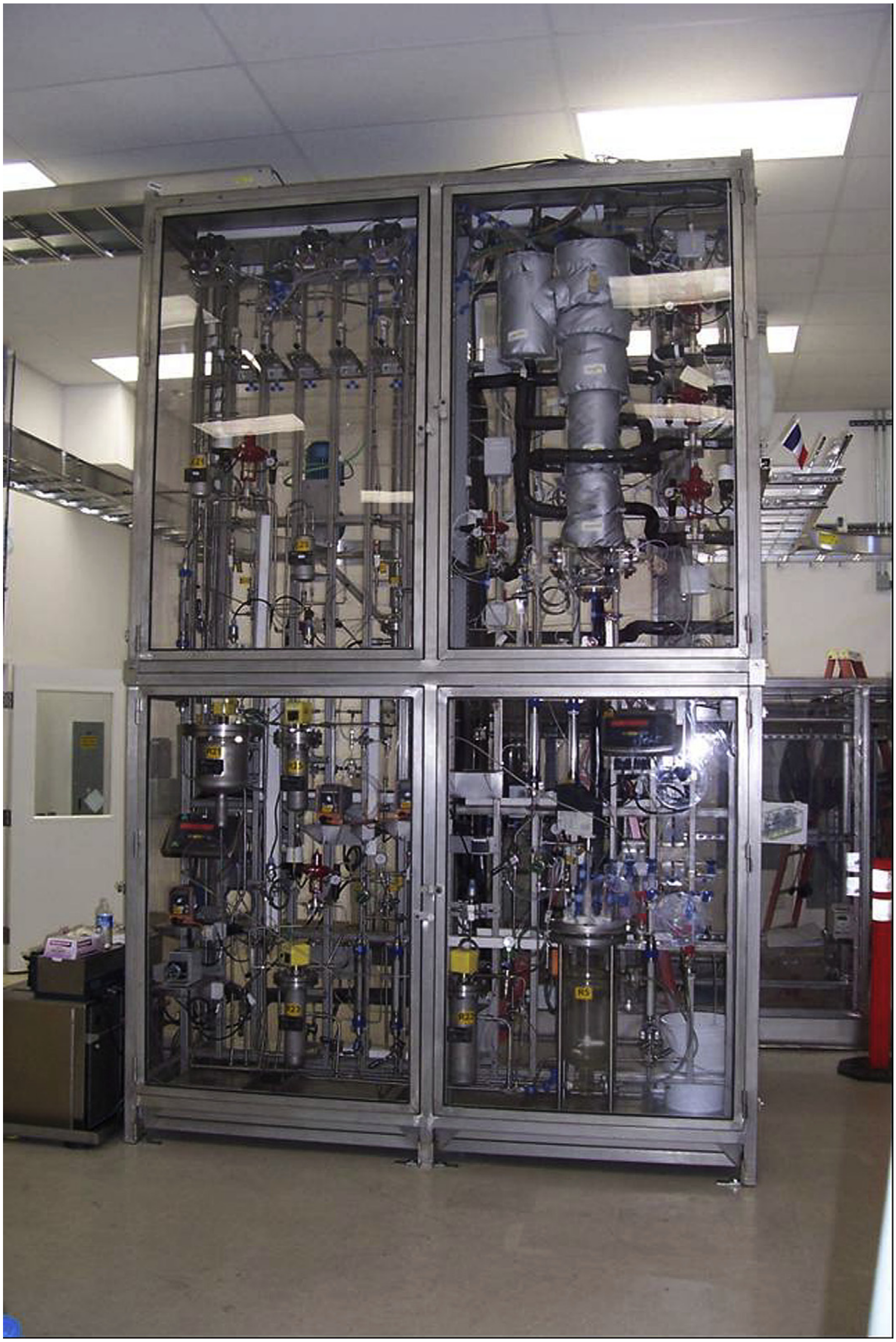

Fig. 1 – CEA Bunsen reactor at GA (San Diego CA).