Improve Sustainability of the Steam Reforming process through high efficiency solutions and use of renewable feedstock

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Highlights

- Increase of hydrogen/thermal efficiency by enhanced thermal integration and process parameters
- Reduction of CO_2 emissions with hydrogen efficiency and gradual replacement of the fossil feedstock
- Economic evaluation of the hydrogen production cost OPEX in all cases

1. Introduction

The efficiency of the Steam Reforming process for hydrogen production depends on the process architecture and operating process parameters. The process integration with high pressure export steam production using the excess heat generated in the steam reforming furnace is a common industrial practice that permits to gain points of thermal efficiency, although hydrogen efficiency, evaluated as Hydrogen/(Feed+Fuel) on LHV basis is penalized. When export steam is not valorized different architectures are introduced, aiming to reduce the excess heat generated and the consequent export steam production.

2. Methods

Different process schemes and operating parameters have been analyzed and compared through process simulation via PRO II 10.0. For all cases Hydrogen efficiency, thermal efficiency and CO_2 emissions have been derived from heat and material balance.
Starting from a conventional process architecture (Figure1, Case A), which is the preferred one when export steam is valorized, we have considered alternative process schemes that can improve the hydrogen efficiency and lower the CO_2 emissions when zero export steam is required. The different alternatives cases (B,C and D) consider respectively the introduction of a pre-reformer, a novel steam reformer reactor with an extended heat recovery (Ref.3), and the introduction of more severe process parameters.

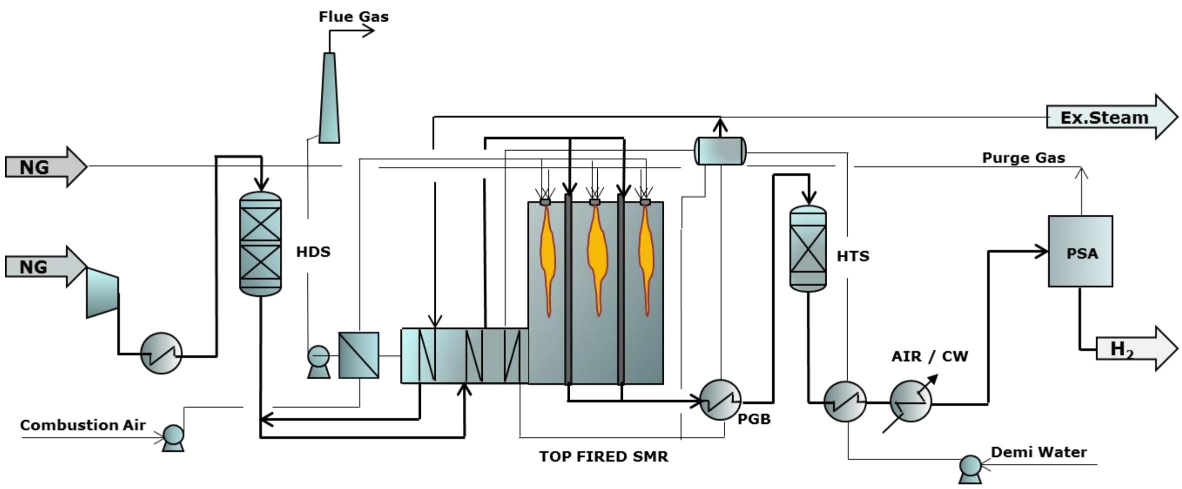

Figure 1. Base Case (A) simplified process scheme

3. Results and discussion

Four different process architectures, with increasing thermal integration and reduced export steam have been simulated and the relevant hydrogen & thermal efficiency evaluated for all cases A, B, C, D (Figure 2)

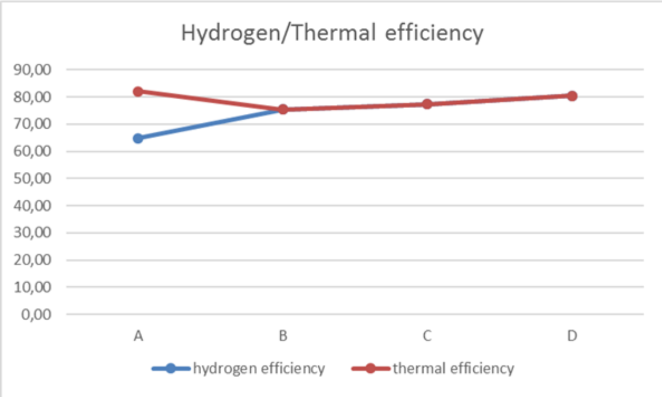

Figure 2. Hydrogen - Thermal efficiency

CO2 emission (kg/Nm^3H_2) decrease in proportion with the increase of hydrogen efficiency and the reduction is directly derived from the efficiency of each case, compared to the base case A.
Further reduction of CO_2 emission can be obtained by substituting a portion of the fossil with renewable feedstock, like biomethane; in this case the amount of fossil CO_2 emitted is reduced without an impact on capital cost. This solution can be applied in principle to any existing hydrogen production unit, provided that a corresponding amount of biomethane is made available. The cost of CO_2 reduction is evaluated for the different cases in terms of $\wedge$OPEX.

4. Conclusions

There is space for further improvement in the efficiency of the steam reforming process for Hydrogen production through conventional and novel steam reforming apparatus and process options. In addition, the introduction of a renewable feedstock like biomethane can represent an economic path to reduce CO_2 emission, thus further improving the steam reforming process sustainability.

References

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Keywords

"Steam Reforming process", "sustainability of hydrogen production", "increased hydrogen efficiency", "Reduction of CO2 emission"