Exergoeconomic optimization of coaxial tube evaporators for cooling of high pressure gaseous hydrogen during vehicle fuelling

Gaseous hydrogen as an automotive fuel is reaching the point of commercial introduction. Development of hydrogen fuelling stations considering an acceptable fuelling time by cooling the hydrogen to -40°C has started. This paper presents a design study of coaxial tube ammonia evaporators for three different concepts of hydrogen cooling, one onestage and two two-stage processes. An exergoeconomic optimization is imposed to all three concepts to minimize the total cost. A numerical heat transfer model is developed in Engineer Equation Solver, using heat transfer and pressure drop correlations from the open literature. With this model the optimal choice of tube sizes and circuit numbers are found for all three concepts. The results show that cooling with a two-stage evaporator after the pressure eduction valve yields the lowest total cost, 45% lower than the highest, which is with a one-stage evaporator. The main contribution to the total cost was the cost associated with exergy destruction, the capital investment cost contributed with 5-14%. The main contribution to the exergy destruction was found to be thermally driven. The pressure driven exergy destruction accounted for 3-9%.

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