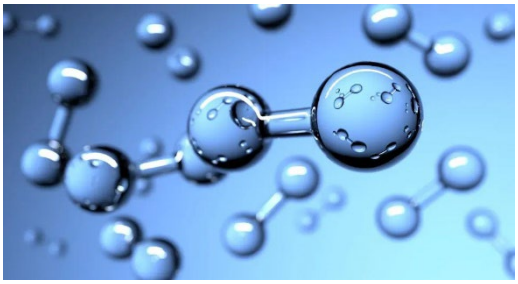
ChE-413: Chemical Engineering Product Design

Exercise set 3

Instructions: Prepare your responses to each of the below questions in the form of a PDF document (not handwritten!). Make sure your name is clearly visible on the document and the pages are numbered. Upload your completed document on the course Moodle no later than one week after the lecture (i.e. by 7th October 2024, 23:59). Each student must upload their own work.

Question 3.1: Storing Hydrogen from Renewable Energy



Over the last few years, hydrogen production from renewable energy has become one of the most promising routes to decarbonizing industry, power generation, and transport. Hydrogen has the potential to address two major challenges in the global drive to achieve net zero emissions. First, it can help solve the issue of intermittency of renewable energy sources such as solar and wind since it can be easily produced via water electrolysis. Second, it can replace fossil fuels to decarbonize sectors where electrification alone is not enough.

There is however one drawback. While hydrogen is an excellent medium for renewable energy storage, it is somewhat difficult to store itself. This is due to its low volumetric energy density (compared to natural gas) which makes it take up significantly more space, even when compressed to high pressures. Alternatively, liquid H2 storage is possible but since it has a boiling point close to absolute zero, specialized cryogenic storage is required.

Hydrogen Europe has mapped out several potential solutions for hydrogen storage. Four of them are:

(i) Geological hydrogen storage
(ii) Liquified hydrogen
(iii) Compressed hydrogen storage at 700 bar
(iv) Sorbent materials-based storage

Before employing any of these methods on a large scale any risks associated with each of the methods need to be evaluated. For this, suggest a risk analysis table and indicate if any of the risks need to be seriously considered.

Question 3.2: Supersonic Air Travel

The Concorde, the first supersonic passenger-carrying commercial airplane, jointly built by French and British manufacturers, made its first supersonic passenger flight in 1976. The high cruising speed of the aircraft, >2000 km per hour, meant a typical London to New York flight would take less than three and a half hours, opposed to the roughly eight hours needed when taking a subsonic flight. While the Concorde was flown on chartered flights to destinations all over the world, the great breakthrough for supersonic transport never came. In 2023 Concorde operations were ceased, with only 14 of the aircraft actually ever going into service.

However, a new era of supersonic flight seems to be on the horizon, with major airlines placing orders for the next generation of ultrafast jets. American Airlines alone has committed to buy up to 20 Overture jest aircraft, which are being developed by the American company Boom Supersonic. United Airlines has ordered 15 aircraft.

So. despite the failure of the Concorde, at least part of the aviation industry seems to believe that supersonic transportation could once more be the future for passenger air travel. This shift from the current standard of passenger air travel (i.e. subsonic flight) to new supersonic planes could come with a variety of risks for commercial airlines. Suggest a risk analysis table and indicate if any of the risks associated with the plan should be seriously considered.