Development of barrier polymeric materials to convert existing methane pipelines into hydrogen pipelines

Marco Luciano
Marco.luciano@unipa.it

Coating for H2 pipeline

Concept

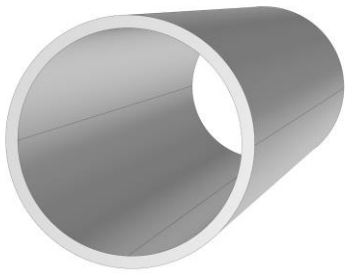
Hydrogen, today, is recognized as the main protagonist in the transition towards renewable energy sources. However, its large-scale transportation poses a considerable challenge due to its physico-chemical nature and limitations in existing technology. Current distribution methods, such as transportation via pipelines, tanker trucks, or ships, are costly and present safety, infrastructure, and emission issues.
Therefore, it becomes necessary to investigate innovative solutions for hydrogen transportation. One possible alternative could be the conversion of the existing natural gas pipeline into a pipeline suitable for hydrogen transportation. The current steel pipeline cannot guarantee a hydrogen flow exceeding 10-15% by volume, as under certain conditions, hydrogen atoms permeate within the network and alter the metal's crystalline structure, reducing its integrity. Adopting an internal coating that protects the steel from direct contact with pressurized H_2 could represent a solution to the embrittlement phenomenon.

Scientific approach

1. Bibliographic study to select eligible materials for experimentation. Specifically, polymers that can achieve high degrees of crystallinity, high density, and specific functional groups are sought.
2. Identification and study of the technology to be applied for the implementation of the coating in existing pipelines.
3. Study and design of a test setup, load conditions, and testing for interpreting mechanical behaviour in the presence of hydrogen.
4. Study and analysis of the liner layer in contact with hydrogen through mechanical tests and solubility tests, after being exposed to hydrogen.
5. Evaluation of the lamination sequence (composite/liner) and study of the interface between the composite and steel.
6. Creation of a predictive model to simulate the behaviour of these materials when subjected to mechanical stress.

Research objectives

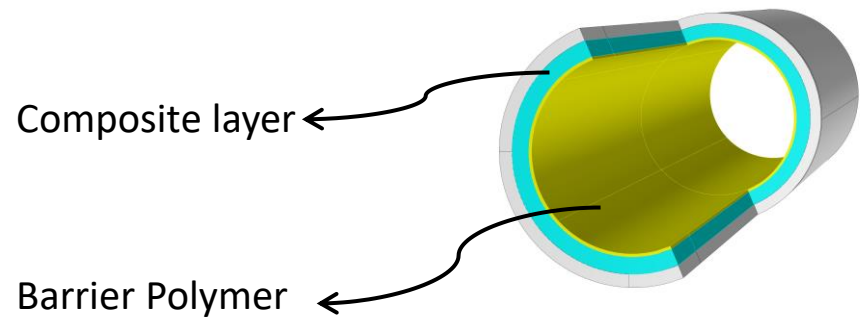
This research has several objectives. The first is to evaluate the behaviour of various materials to be applied as an internal liner, through mechanical and chemical tests.
The second phase aims to select the type of materials that make up the composite, placed between the liner and the steel pipeline. This choice is based on sustainability requirements, good interfacial adhesion between the three components, and applicability to the adopted implementation technology.
Finally, it is planned to perform mechanical tests on the entire system, once it has been exposed to hydrogen, in order to evaluate the possible decay of the mechanical characteristics.



Pipeline Steel for natural gas:

- X52
- X56
- X60
- X65
- X70

Pipeline for H_2



- HDPE
- PP
- PI
- PU
- PE
- PA

Chemical analysis:

- Gas cromatography
- X-ray diffractometer
- DSC

Mechanical Analysis:

- Bending test
- Impact test
- SBS test
- DCB test
- Fatigue test
- Corrosion test