



# Environmentally Friendly Tire Recycling Facility for Hydrogen Production: Sustainable Solutions for Waste Management



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**TEAM DESIGN:** 40

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## INTRODUCTION & BACKGROUND

In response to the growing environmental concerns surrounding tire waste, there is a significant push towards sustainable solutions for recycling used tires. Currently, tires end up being burned in landfills, causing severe air pollution and wasting valuable, non-renewable materials called hydrocarbons, which are integral to the tire structure. Instead of wasting these valuable resources, our approach will provide a sustainable source of hydrogen, carbon black, and steel wires, while depending 58% on renewable energy (solar energy) to operate the plant. Additionally, applying CO<sub>2</sub> reforming technology minimizes CO<sub>2</sub> emissions while enhancing hydrogen production.

**Hydrogen production:** To create a local and sustainable resource for clean energy solutions, supporting the transition to a green hydrogen economy and reducing fossil fuel dependence.

**Solar energy integration:** By using solar power for 58% of energy needs, the plant reduces fossil fuel reliance, lowers emissions, and supports Saudi Arabia's Vision 2030 for clean energy.

**Project Statement:** Environmentally friendly tire recycling facility for hydrogen production: sustainable solutions for waste management.

### IDENTIFICATION OF CONSTRAINTS:

#### Pyrolysis Temperature

The pyrolysis reactor must operate at a high temperature (typically 800°C to 1200°C) in an oxygen-free environment to thermally decompose the tire feedstock.

#### Separation Unit Efficiency

The separation unit should efficiently separate the solid products (carbon black, steel wires) and gaseous products (syngas).

#### Steam-to-Carbon Ratio

Gasification requires precise control of steam-to-carbon ratio, temperature (around 1000°C to 1500°C), and pressure to convert pyrolysis oil into hydrogen-rich syngas.

### TARGET SPECIFICATION:

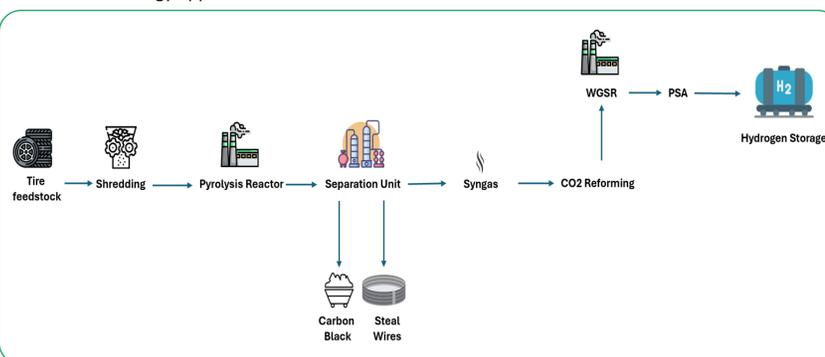
The purity of the Hydrogen must be above 99%.

Steam-to-carbon ratio: 2.5 to 3.0 at 1460°C and 15-30 bar pressure.

Hydrogen to feed ratio ≈ 0.158

## 1- PROCESS OVERVIEW:

Tires are shredded and fed into a pyrolysis reactor, where high heat decomposes them into carbon, steel, and syngas. The carbon and steel are separated for reuse, while syngas undergoes CO<sub>2</sub> reforming and a water-gas shift reaction (WGSR) to produce hydrogen. A Pressure Swing Adsorption (PSA) unit purifies the hydrogen, which is then stored for industrial or energy applications.



## VALIDATION

Specifications	Results
Steam-to-carbon ratio: 2.5 to 3.0 at 1460°C and 15-30 bar pressure.	Meet (S/C = 2.6)
Hydrogen to feed ratio 0.158	Meet (Hydrogen/Feed = 0.435)
The purity of the Hydrogen must be above 99%.	Meet (Purity of Hydrogen Achieved = 99.2%)

## PHYSICAL PROTOTYPE

The purpose of our prototype is to visualize the idea of the pyrolysis process. We will use plastic instead of tires and convert it into pyrolysis oil due to our limitation



Aluminum pressure cooker acting as our reactor. Capacity: 7 liters



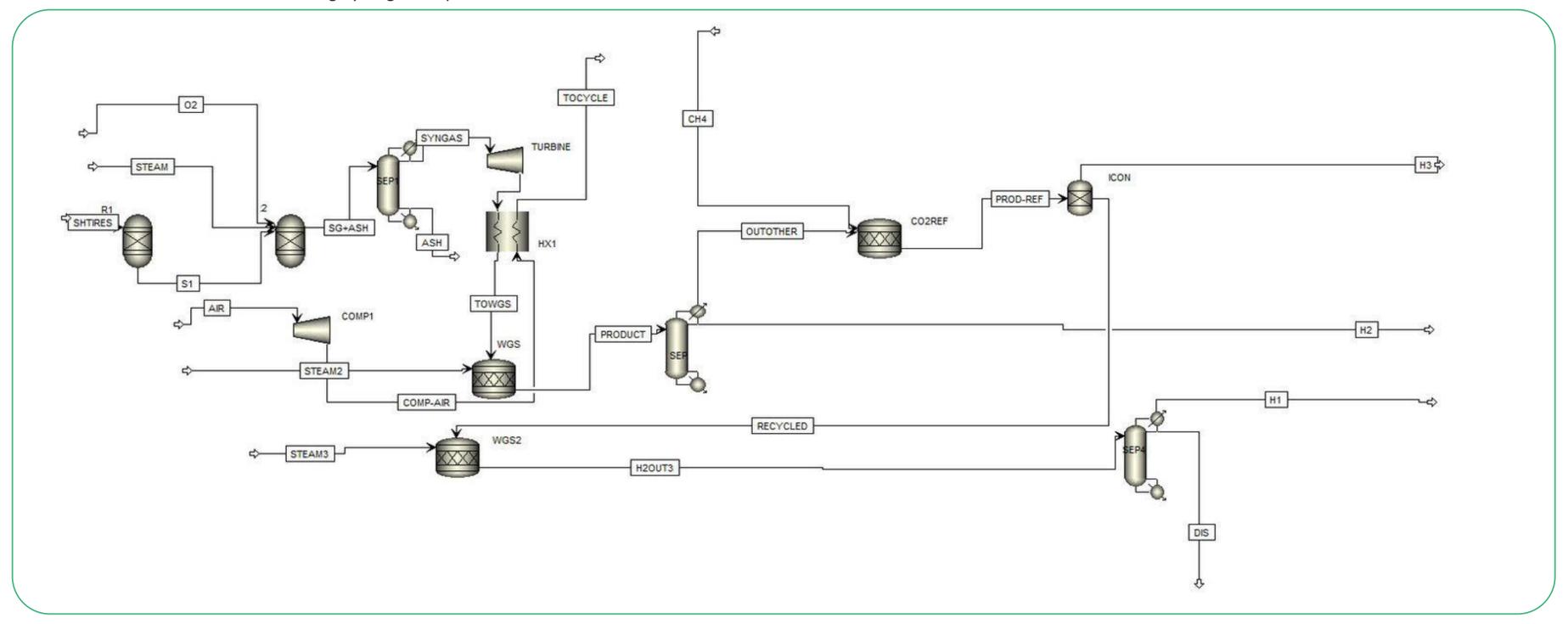
The fluid coming from the reactor is transferred by a hose. PVC, 1/2 in



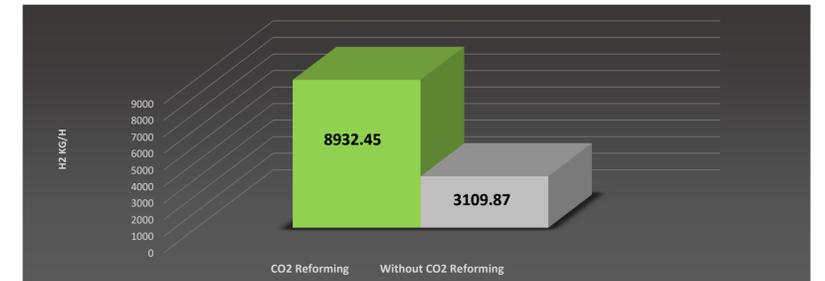
A container of water is used to act as a heat exchanger to allow the gas to be converted to liquid. 15.4 L

## ASPEN PLUS DESIGN:

Aspen simulation for hydrogen production from waste tires involves a sequence of key processes. First, the pyrolysis reactor breaks down waste tires into syngas and char, which are then fed into the gasification unit to enhance hydrogen-rich gas production. The syngas is further processed through a water-gas shift reactor to increase hydrogen yield and a CO<sub>2</sub> reforming reactor to minimize CO<sub>2</sub> emissions while maximizing hydrogen output.



## Effect of CO<sub>2</sub> Reforming on Hydrogen Production



## CONCLUSION

An efficient and promising route has been developed for producing high-purity hydrogen (99.2%) from waste tires, addressing both energy and environmental imperatives. This process applies different pyrolysis and gasification steps with Aspen Plus modeling in order to maximize hydrogen yield while minimizing CO<sub>2</sub> emissions. Among the key specifications are a steam-to-carbon ratio of 2.6 and a hydrogen-to-feed ratio of 0.158, which allow appropriate scaling and efficiency of the system. This approach integrates renewable energy into the solution, meeting global sustainability goals by turning waste into resources while reducing reliance on fossil fuels.

### OUTCOMES

- Converting waste tires into valuable biproducts: carbon black & steel wires.
- Sustainable & Local source of Hydrogen.
- The utilization of green energy in high emission plants.