Final Year Design Project Showcase
Batch-2022
Year 2026

Department: Automotive & Marine Engineering Programme: BE in Automotive Engineering	
1	**Project Title** Design and Analysis of Hydrogen Fuel Tank for Automobiles
2	**Project Idea** Depletion of fossil fuels led everyone's attention towards hydrogen as it is a clean source of energy which shifts our focus on the designing of a Type IV composite hydrogen storage tank capable of safely storing gaseous hydrogen at 70 MPa for use in fuel cell vehicles. One of the biggest engineering challenges is storing enough hydrogen on-board a vehicle without compromising safety, given hydrogen's very low volumetric density at ambient conditions. We designed a tank consisting of a High Density Polyethylene (HDPE) liner overwrapped with carbon fiber composite layers, optimized the tank's geometry and composite ply layup using ANSYS Workbench, and validated the final design against the international safety standard ISO 19881 for gaseous hydrogen land vehicle fuel containers. The project also included thermal-structural analysis under both parked and moving vehicle conditions to confirm the tank remains safe under real-world temperature variation.
3	**Process** We began with a parametric study of the tank's geometry defining its length, diameter, fillet radius, and boss hole diameter. Used ANSYS response surface optimization to identify the ratios that minimize peak stress while keeping a practical storage volume. Following this, we performed a composite analysis to get the best composite thickness, ply sequence, and ply angle. A thermal analysis was conducted at the end to validate the tank's strength against temperature changes. Key steps included: • Response surface optimization of geometric ratios (diameter-to-length, fillet-to-diameter, hole-to-diameter) to minimize peak stress. • Netting analysis to determine the minimum composite thickness (25 mm) required to withstand 70 MPa. • Design-of-experiments testing of four candidate composite ply sequences, evaluated through FEA in ANSYS Composite PrepPost (ACP). • Selection and refinement of the best-performing sequence (90°/55°/20°/55°), correcting an under-performing helical ply angle from 20° to 40° to meet the target safety factor. • Thermal-structural analysis under parked and moving vehicle conditions using natural and forced convection correlations, with the layup revised where required.

	This workflow combines analytical sizing methods with iterative finite element validation, resulting in a design that is both computationally efficient to develop and rigorously verified.
4	**Outcome** We delivered a fully optimized Type IV hydrogen storage tank design that meets the safety requirements of ISO 19881, achieving a target factor of safety of 2.25 across all composite plies under the 70 MPa nominal working pressure. The final design also maintains internal pressures safely below the 157.5 MPa burst limit under both parked (74.2 MPa) and moving (80.0 MPa) thermal loading conditions. This validated design and analysis framework can now serve as a foundation for local prototyping and testing of hydrogen storage tanks for automotive and industrial applications in Pakistan, reducing dependence on imported tank designs and engineering expertise.
5	**Evidence (Theoretical Basis)** Our project was developed in line with ISO 19881:2018 (Gaseous Hydrogen — Land Vehicle Fuel Containers) and ISO 15869:2009, which govern the safety, burst pressure, and fill pressure requirements for automotive hydrogen storage tanks. The design applies core theories from composite laminate mechanics (netting analysis for ply thickness and winding angle), pressure vessel theory, and heat transfer (Churchill–Chu and Zukauskas correlations for natural and forced convection). We used ANSYS Workbench, ACP, and Response Surface Optimization to computationally validate the tank's stress distribution, ply-level safety factors, and thermal-pressure response.
6	**Competitive Advantage or Unique Selling Proposition** Our project offers a clear advantage by building in-house, locally developed expertise in Type IV hydrogen tank design, a capability that currently does not exist widely in Pakistan and is otherwise sourced through costly foreign consultancy or licensed design packages. It demonstrates a validated, standards-compliant (ISO 19881) design and optimization methodology using accessible simulation tools, making the process replicable and scalable for local research institutions and manufacturers, while directly supporting Pakistan's clean energy transition by building the technical foundation needed for a domestic hydrogen mobility ecosystem.
a	**Attainment of any SDG:7,9,12,13** This project directly supports SDG 7 (Affordable and Clean Energy) by advancing the storage technology needed to make hydrogen a viable, safe fuel for everyday transportation. It contributes to SDG 9 (Industry, Innovation and Infrastructure) by building local R&D capability in composite pressure vessel design, an area with negligible existing expertise in Pakistan. The project supports SDG 12 (Responsible Consumption and Production) through material-efficient design optimization that minimizes composite usage while meeting safety requirements, and SDG 13 (Climate Action) by enabling a zero-tailpipe-

	emission fuel storage solution. These contributions are especially relevant for a country like Pakistan, which remains heavily reliant on imported petroleum fuels and could benefit significantly from locally developed clean energy infrastructure.
b	**Any Environmental Aspect** The core motivation of this project is environmental. Hydrogen fuel cell vehicles emit only water vapor, eliminating the carbon and nitrogen oxide emissions associated with petroleum-fueled transportation. The composite ply optimization process was specifically designed to minimize material usage while still meeting the required safety factor, reducing carbon fiber and resin consumption per tank.
c	**Cost Reduction of Existing Product** Commercial Hydrogen Storage tanks cost around 7000 USD for storing 5 kg of Hydrogen. We reduced the required amount of thickness and layers by reducing the stress which was done by optimizing the geometry. This led to reduction in the material requirement of the carbon fibre which is the most costly in the development of the hydrogen tank. This optimization has approximately reduced the cost by 20 %.
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** Usual Hydrogen tank development includes random angle fibre enforcing, but we on the other hand optimized the angles of the Carbon Fibre to improve the overall efficiency of the Tank. ● First, we have a 90 degree hoop layer which takes care of the hoop stress which occurs at the start of the layers of Carbon Fibre. This is the best strategy to reduce the overall thickness of the fibres for improvement. ● Second, we optimized the helical layers which balance both the longitudinal and hoop stresses efficiently instead of random fibre reinforcement. These two steps single handedly optimized the fibre reinforcement technique of the development of the traditional Hydrogen Storage Tank.
e	**Expanding of Market share** The global market for Type IV hydrogen storage tanks was valued at roughly USD 1–2 billion as of 2024–2025 and is projected by multiple industry analyses to grow at a compound annual rate in the range of 12–20% through the early 2030s, driven by rising fuel cell vehicle adoption, and expanding hydrogen refueling infrastructure. Despite this growth, almost all Type IV tank design and manufacturing expertise is currently concentrated among a small number of international figures, with negligible presence or local capability in South Asia. By developing and validating an in-house design methodology, this project lays the groundwork for Pakistan-based academic institutions and manufacturers to eventually participate in this expanding market rather than remaining solely import-dependent.

f	**Capture New Market** This project targets an underserved niche: academic institutions, automotive research groups, and early-stage industrial developers in Pakistan and similar emerging markets who currently have no access to local Type IV hydrogen tank design expertise and cannot justify the cost of importing complete foreign-designed systems for research or pilot-scale development. By demonstrating a complete, standards-compliant design and optimization workflow using accessible simulation tools, the project opens the door for local universities and automotive component manufacturers to begin developing in-house hydrogen storage capability rather than depending entirely on imported systems.
g	**Any Other Aspect** Beyond its direct engineering outcome, this project serves as a foundational academic resource for teaching composite pressure vessel design, finite element analysis, and hydrogen safety standards. Its multidisciplinary scope spanning mechanics of materials, composite design, thermal analysis, and international safety standards makes it a valuable reference for future final year projects, coursework, and research at NED University and other institutions building hydrogen engineering capability.
7	**Target Market** The primary target audience for this design methodology includes: ● Engineering universities and research institutes seeking to build local expertise in composite pressure vessel and hydrogen storage design. ● Automotive OEMs and component suppliers exploring early-stage hydrogen fuel cell vehicle development in South Asia. Government and academic bodies focused on building Pakistan's technical capacity for the emerging hydrogen economy.

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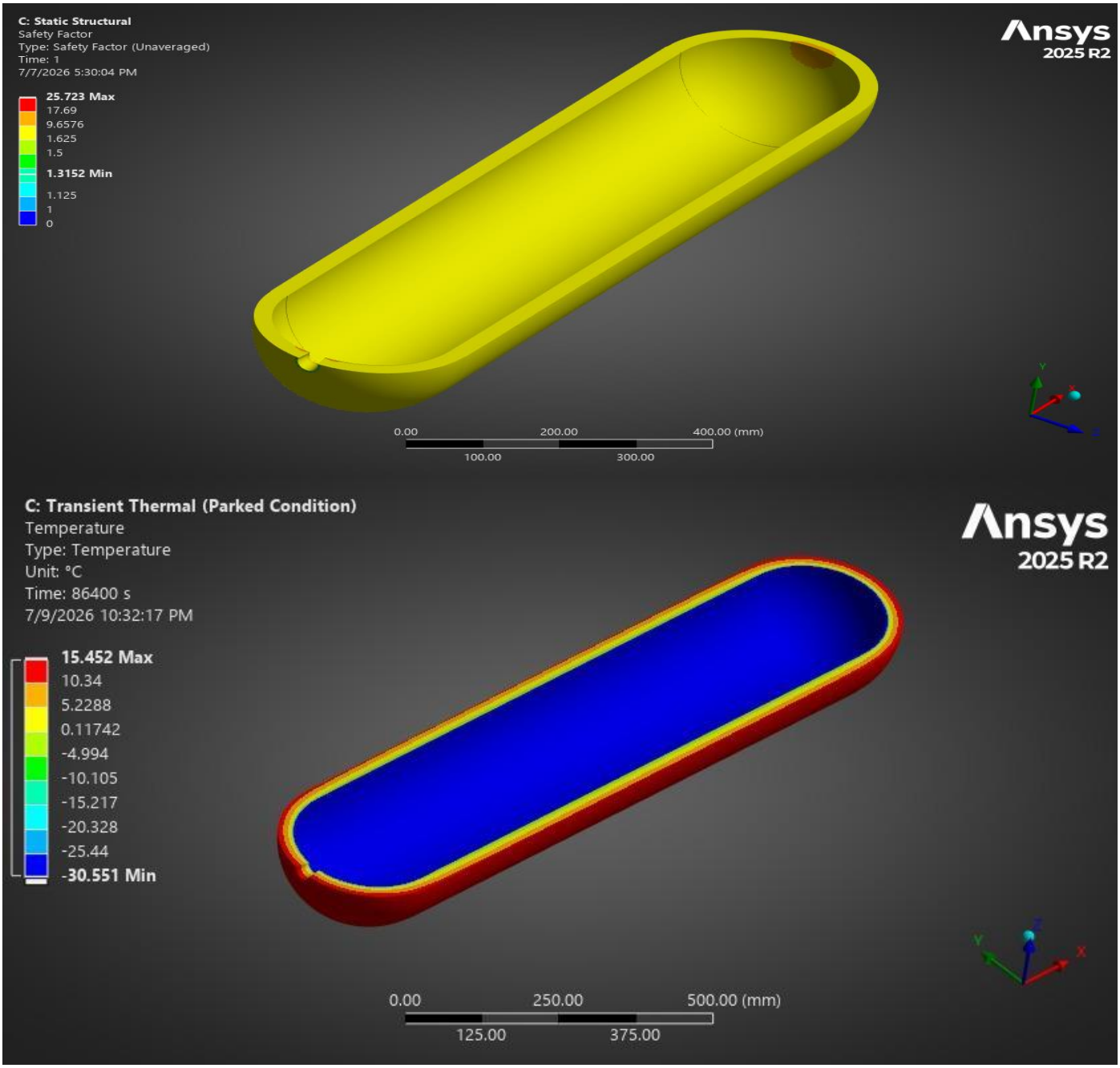
11	**Video (If any)**	NA

Pictures (to be pasted below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