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Review of Composite Pressure Cylinders used in different Vehicles

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Abstract: ***Natural gas is an eco-friendly source of energy due to its wide availability and safety during operation. It is a viable solution for current environment threat of pollution; however the transportation problem due to low density restricted its wide usage. Burst pressure prediction helps to estimate the load carrying capacity of vessel and prediction of burst pressure in different working condition is cumbersome work. Finite element method and continuum damage mechanics study used to study burst pressure. FEM techniques various model used to predict stress and burst pressure in academic scenario.***
Keywords: CNG cylinder, Composite, Burst Pressure, FEM, Vehicles

I. INTRODUCTION

Natural gas is an eco-friendly source of energy due to its wide availability and safety during operation. It is a viable solution for current environment threat of pollution; however the transportation problem due to low density restricted its wide usage. Less calorific value of natural gas than petrol and diesel is most unfavorable. Consequently, usage of Compressed Natural Gas (CNG) accumulated at pressure like 20 MPa at atmospheric temperature or as Liquefied Natural Gas (LNG) at cryogenic temperature like − 162 ◦C at normal pressure. Chemically natural gas is normally consists more than 90% methane gas with combination of ethane, propane, butane and carbon dioxide. Due to high methane percentage it has high octane number with clean combustion properties results high engine efficiency. In present scenario focuses on the progress of light-weight container to store up compressed natural gas. In addition to this composite material pressure vessels used to achieve weight reduction over metallic cylinders [1].

Composites are synthesized material that is obtained from multiple ingredient with different physical, chemical and thermal properties. Pragmatically product exhibits individuality and combination of qualities also. Fiber-reinforced polymer composites (FRPC) are defined as plastic which made from reinforced fibres of polymer resin matrix. Commonly used fiber ar carbon, armid, glass etc as well as other types asbestos wood and paper have been used as per different requirements. Thermostatic plastic like polysester vinyl ester and epoxy also used in different environment [2].

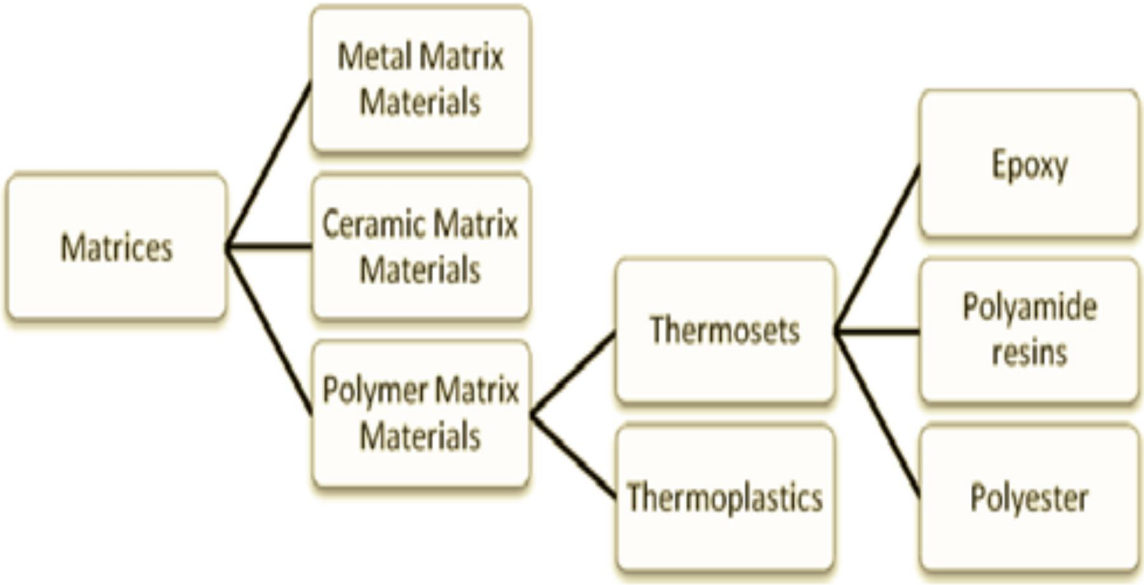


Fig.1 Composite Matrix

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II. LITERATURE REVIEW

For current work, overall comparison taken in past years, development of different research condition and safety measures are key factors are in research review. Some important papers having direct impact on topic are covered.

A. G. Bhattacharjee et. al. [3] studied accidental risk phenomenon for CNG vehicle like bus due to large storage of fuel. Overall bulky structure of the bus trapped the gas and causes ignition and explosion. Researchers mainly suggested the different like appropriate design of bus and safety measures. Safety inspection of CNG cylinder should in every 3 years as a scheduled maintenance. There should be periodic maintenance for corrosion and cyclic loading test as per ANSI (American National Standards Institute) standard. There should be proper safety checks and dos and don'ts list inside the bus for less human errors. Periodic leak test and maintenance by appropriate authorities should be maintained. There should emission testing and certification for vehicle. Researcher also study the accident related to unauthorized gas filling in India. Further investigation shows the unauthorized cylinder fitting without approval from manufacturer.

B. Majid Mirzaei et.al [4]states catastrophic failure of a compressed natural gas (CNG) fuel tank by simulation. The preliminary testing observed the cracking and fracto graphic pattern of cylinder failure by finite element transient-dynamic elasto-plastic. Analysis shows three dimensional brick model to investigate cohesive elements crack analysis. Results shows the failure characteristic with fracture deformation and asymmetric deformation in multiple cracking at the neck. Research work is carried out by software package ABAQUS. Study carried out for moving. Results showed the pressure is act on radial direction of cylinder by finite element method.

C. B.S. Kimet.al [5] studies high density polyethylene liner vessel's end nozzle burst test. Design and analysis on metal end nozzle. Results show that carbon epoxy composite with polyethylene liner s lighter than aluminum. Composite pressure vessel shows safer behavior as compare to metallic cylinders. Study includes mid size vehicles and focuses on operating and burst pressure.

D. Mayank Nirbhay et. al [6] simplify the secure processes pressure with CNG composite cylinders. By using ANSYS, finite element tool diverse operation provision to study different failure of CNG vessels were proposed. Materials like glass epoxy as well as carbon epoxy were tested as per condition in composite cylinder design. The working stresses were found 1498 MPa for carbon fiber and 870 MPa for glass and carbon fiber combination. All tests are done in three pressure range i.e. 20 MPa, 30 MPa and 73 MPa.

E. Pranjali Sharma et. al [7] studied different composite pressure vessels for automotive applications for their lightweight properties for the reason that of their capability to stock up high pressure gaseous fuel. Study compromises design factors to reduce burst and leakage in Type 4 cylinders. Design also suggested the optimized manufacturing to enhance product performance. Results validation of design had done by comparison of experimental burst pressure. After validation, lightweight as well as economical vessel manufactured as per design consideration to analyzed burst pressure. Study focused on manufacturing of type 4 vessel as per design with experimental data as well as also focused on Manufacturing defects like slippage of fiber and winging brakeage can be eliminated by simulating bursting pressure. The planned methods also concluded the different volume of pressure vessels and composite layers thickness with their numbers prevents different failures. Estimated cost of cylinder is near about 50000/- INR found economic as compared with available cylinders in marketplaces with certification of ISO 11439 ranges 50MPa.

F. Eui Soo Kim et. al [8] targets the threats of fossils fuel in comparison with CNG gases vehicles with environmental issue. There should be a reliability regarding storage of CNG tanks to avoid traveler losses and damages. By use of fractography, failure identification had done to overcome fracture of vessel and fire. The design of vessel was validate with the help of finite element method. ANSYS applied in design and analysis of composite cylinders with their mechanical properties and chemical properties with the help of fractography method. Stresses value up to 850 MPa satisfies the design result in the case of the bursting pressure. Vessel divided in three studied zone upper part consisting dome, ruptured part or middle part and last dome part related to lower part. Crack formation initiated from middle part and lower dome also affected in clamp bolt and vessel junction.

G. Zhong Yue et. al. [9] studied the failure of composite CNG cylinders of vehicles generally sourced by crakes of cylinder liners. Research carried out on ANSYS software to analysis test pressure and bursting pressure at different operating pressures. Inadequate strength of liner and irrational construction of cylinder causes failure. To overcome this there should be improved design of structure necessary if cylinder body to valve. All composite gas cylinders at different conditions with different loads and constraints analyzed on ANSYS software used with von misses cloud diagrams. As per the definite circumstances all cylinders are verified with safety and reliability constraints. The maximum hoop stress displacement under 20 MPa, take place inside body section of gas cylinder. The values of hoop stress displacement are 5.134mm and 0.387 mm within elastic range. The distribution of axial displacement and hoop displacement of the gas cylinder under 30 MPa was basically the same as that under 20 MPa, and only the strain was increased under 30 MPa, compared with that under 20 MPa, but it was within the

elasticity range of material. Under 73 MPa, the all-composite gas cylinder had large axial deformation, its max axial displacement was 2.98 mm and its elongation reached 1.12%; its hoop displacement was also large with max value up to 18.738 mm and min value of 0.828546 mm. The hoop displacement at most places of the gas cylinder was within 5–7 mm, which is within the allowable range of material, and local displacement was too large with elongation up to 6.38%, which exceeds the max elongation of material, 5%.

H. K. Rajendra Prasad et al.[10] represent the design and finite element study on high pressure cylinder of different epoxy composites. Cylinders at high pressures are generally used in automobile as well as aerospace projects. Pressure cylinder developed different pressure constraint like hoop and longitudinal. Comparing different fiber reinforced material with high specific strength at different condition of pressure. Pressure cylinders like UD epoxy carbon shows less weight as compared with conventional material and shows less stresses and deformation. Internal pressure ranges under 14 MPa for different application like CNG Auto composite materials are the greatest alternative.

I. Tsyss V.G et al. [11] simulate the cylindrical shell made by composite material of anti vibration pipe. Study focused on stress strain state by finite element method of pipe of stress-strain state caused with excess pressure was carried out. Conducted test shows the weak areas where maximum loading had done in terms of rubber cord array. Analysis figures represent the upper and lower layer identical stresses. The A programming loop determined the nodal values average by linear interpolation formula. Results confirm the friction coefficient between outer rubber and metal flange is 0.5 and other between the rubber and shell cord is 0.9.

J. V. Mohanavel et. al. [12] researches for installation of aluminum composite cylinder material in place of conventional metallic cylinders. Basically this type of matrix composite of Aluminum worked with higher specific strength and also reduce weight if structure. Researchers prepared this alloy base matrix compound of aluminium (AA6082) by stir casting and also examine the mechanical properties like tensile test and hardness test with weight ratio. Internal pressure calculation by finite element method of aluminum stresses. Overall design made in Solid works software and further analyzed by ANSYS software. Steel pressure vessel results compared with composite material results. Graphical curves show the different stress deformation and equivalent strain values of composite aluminium matrix.

III.KEY FINDINGS

In above review of literatures guided the present research work in definite manner with these findings. First the overall safety of vehicles are directly depends on safe driving and proper training of driver. Accidents could be avoided with better driving skills and standard policies of driving. However an accident affects the safety of passengers, design of proper pressure vessel and safety construction can avoid hazards of bursting of cylinder and decrease the causalities. Combination of proper composite material increases the strength and working of cylinders in different pressures. Also cost factor is involved during construction and manufacturing of pressure vessel. Uses of different composites are also helpful in design and construction of pressure vessel for compressed natural gas.

IV.CONCLUSIONS

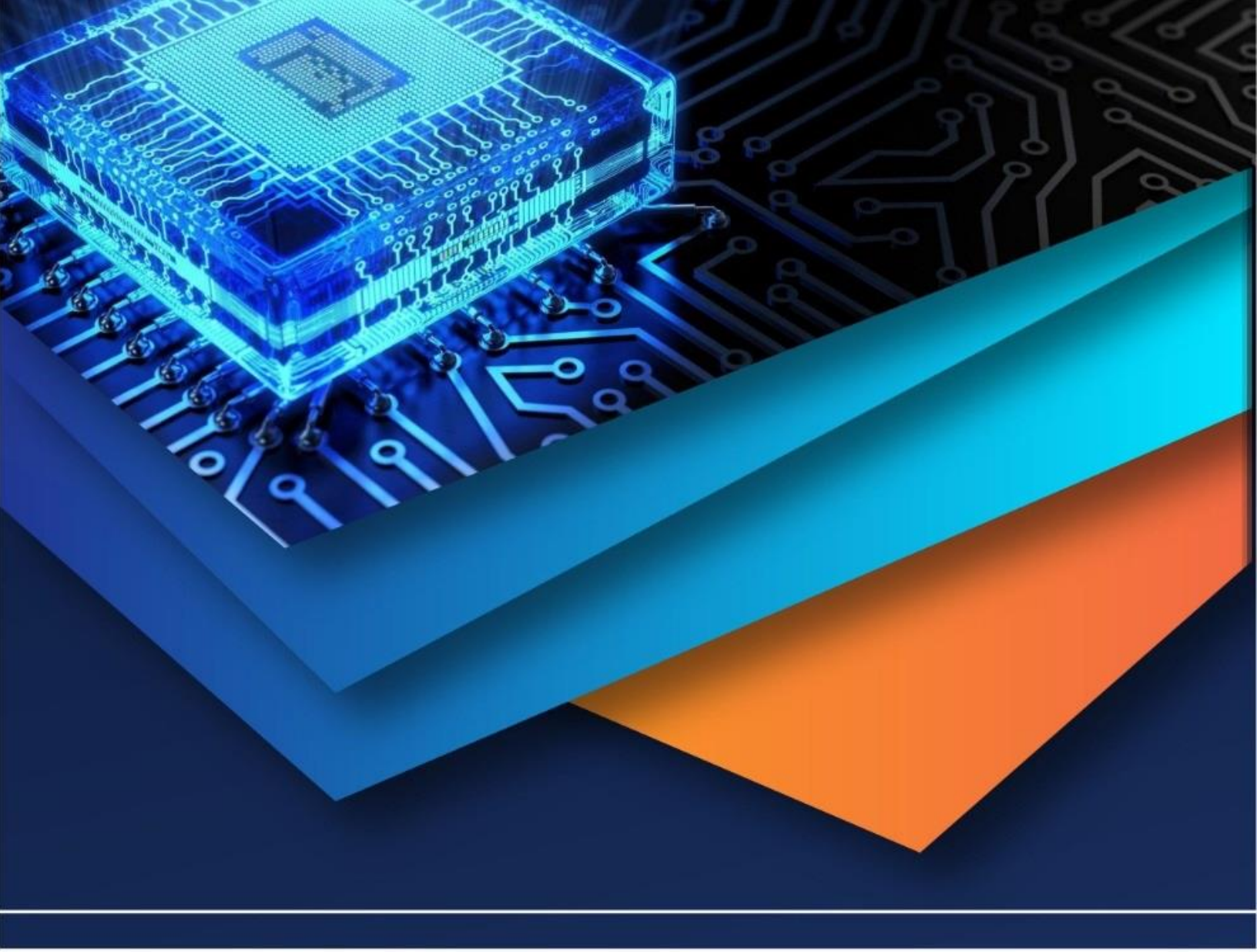
As per literature review, there are some key points emerges, there is some safety measures which are useful to prevent accidents and causalities due to breakage or leakage of compressed gas cylinders of vehicles, training to driers and co drivers can also prevent hazards effect of bursting during accidents. In design consideration there should be lighter material to overcome weight ratio and balance vehicle weight. There is Type 4 type composite cylinders which are useful and give higher strength. There are possibilities to find better materials to giver better strength with lower density and lower in weight also.

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