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Gas Tank for Cars

In this work the development of a highly efficient pressure vessel for liquid petroleum gas (LPG) in integral design is described. The pressure vessel can be customized in an optimal available installation space and thus means that the suitable for everyday use of existing modified cars or trucks can be increased.

***Keywords**: pressure vessel, LPG, Liquefied Petroleum Gas, space optimization*

1. Introduction

Due to the ever-rising crude oil prices in the recent years, many different alternative energy concepts have been developed for motor vehicles. Most of these concepts are not yet being fully developed or there are currently far too expensive and therefore not ready for mass production. Usually there are only concept cars or smaller vehicle fleets for testing and research. For example, the batteries for electric cars are still much too expensive and heavy, and allow only short distances to drive.

Fuel cell technology seems promising, but there are still many problems to solve, so the storage of which is under high pressure hydrogen is expensive because the need to ensure that arises in an accident not a disaster by the highly reactive hydrogen.

Liquefied petroleum gas (LPG), however, has carved out in recent years, a permanent place among the alternative fuels. LPG or liquified petroleum gas is a low pressure liquified gas mixture composed mainly of propane and butane which burns in conventional gasoline combustion engines with less CO_2 than gasoline. Gasoline cars can be retrofitted to LPG and become bifuel vehicles as the gasoline tank stays. You can switch between LPG and gasoline during operation. Estimated 10 million vehicles running worldwide [1], [2].

Injection of LPG into a diesel engine has many advantages. Foremost is: Reduction in Gross fuel consumption reducing running costs; Increase in torque, primarily at lower RPM; Major reduction in sooty discard from the exhaust. The LPG does not replace the diesel fuel, it acts as a catalyst to increase the burn efficiency of the diesel. Typically diesel engines have a burn efficiency around 75 to 80%. When LPG is injected into a diesel engine, the burn efficiency can be increased to around 95 to 98%. The result is less total fuel consumption, reduced running cost and increased engine torque.

LP gases are actually quite safe in comparison with other fuels. Propane has a high ignition temperature, about 850-950 F (450-510° C), compared to about 495 F (257° C) for gasoline. This makes it less likely to ignite spontaneously. Also, the tanks used to store propane are stronger than gasoline tanks because of the pressure needed to keep the propane in liquid form. This makes on-board propane storage safer than a typical gas tank - it is more resistant to rupturing in the event of a collision. Special safety valves and cut-offs increase the safety factor. To store LP gas safely, there are some guidelines. It's important to remember that a propane tank is never really empty. When the tank is filled, most of the propane is under enough pressure that it is in liquid form. But at safe pressures, not all of the propane is liquefied, a small amount is in gas form, filling up the rest of the space in the tank. As more propane is used, the pressure decreases, leaving less propane in liquefied form and more propane gas filling up the remaining space. Tanks should only be filled to roughly 80 percent capacity. Changes in temperature can change the pressure inside the tank. If you were to fill your tank to 100 percent on a cool, cloudy day, and then leave your car out in the sun the next day, the increase in temperature would cause in increase in pressure within the tank that could cause it to fail without that 20 percent headroom [3].

There are various reasons, but above all it is possible to convert an existing vehicle without much effort with a combustion engine to LPG. It will be carried out only small modifications to the engine and installation of a gas tank in the vehicle.

Figure 1. Spare wheel tank and bottle tank in trunk [1]

These tanks are usually installed. This has the disadvantage that valuable storage space is wasted in the trunk and the daily use, depending on vehicle type is limited more or less.

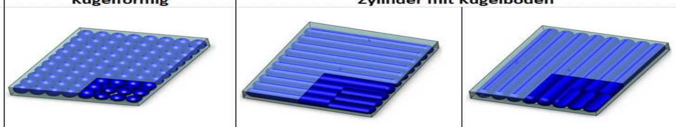
These tanks are usually installed in the space for the spare wheel well as a toroid body or as a conventional pressure bottle in the trunk (Fig.1).

The aim of this study was to develop a space-saving pressure vessel for liquefied petroleum gas, which exploits a given installation volume and can be optimally adapted to different installation spaces.

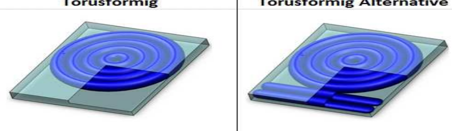
In contrast to traditional, classical solutions, which are usually in all three spatial directions at least equally extended in two directions, the pressure vessel presented here is built very flat to save space and can be used for example as an underfloor tank in the vehicle [1], [2], [3].

2. Development and construction

For the development different designs of classical pressure vessels have been fitted into a given space, so that the maximum utilization rate was realized for each type. Then the properties such as weight, volume and utilization rate were compared (Fig. 2).



		Kugelförmig	Zylinder mit Kugelboden	
Variante Nr.		1	2	3
Bauraum		1150x910x110	1150x910x110	1150x910x110
Anzahl Körper	[-]	80	10	8
Wanddicke	[mm]	1,6	2,5	2,5
Volumen / Körper	[l]	0,638	7,57	9,655
Gewicht /Körper	[kg]	0,461	5,64	7,219
Gesamtvolumen	[l]	51,027	75,77	77,238
Gesamtgewicht	[kg]	36,859	56,39	57,75
Volumenausnutzung	**[%]**	**44,3**	**65,8**	**67,1**
Gewicht / Volumen	**[-]**	**1,384**	**1,344**	**1,337**



		Torusförmig	Torusförmig Alternative
Variante Nr.		4	5
Bauraum		1150x910x110	1150x910x110
Anzahl Körper	[-]	4	4+2
Wanddicke	[mm]	2,5	2,5
Volumen / Körper	[l]		
Gewicht /Körper	[kg]		
Gesamtvolumen	[l]	51,14	65,740
Gesamtgewicht	[kg]	38,9	50,7
Volumenausnutzung	**[%]**	**44,4**	**57,1**
Gewicht / Volumen	**[-]**	**1,315**	**1,297**

Figure 2. Comparison of classical pressure vessel concepts for a given flat space

First in the development process, for the calculation of the specific needed wall thickness, the classic formulas for building pressure vessels were used and analyzed [4], [5], [6]. These results were then compared with FEM analysis of the respective tank concepts in order to make statements about the actual stress conditions prevailing in reality, (Figure 3). These results could then be taken to the search for the optimal cross-sectional shape for the pressure vessel.

The starting point was the concept with the adjacent cylinders, as was already evident in the above comparison, that this solution has a relatively good capacity utilization rate of approximately 66%.

By geometry variations and simulation parameters and with the help of modern computer programs then was determined which design form was ultimately chosen. A comparison of the FEM analysis shows a very low stress distribution over the cross section (Fig.4). In particular, the inner walls are only exposed to tensile stresses beneficial and can therefore be constructed with low thickness. Only the two outer walls are rounded out, as they must be supported against the ambient pressure.

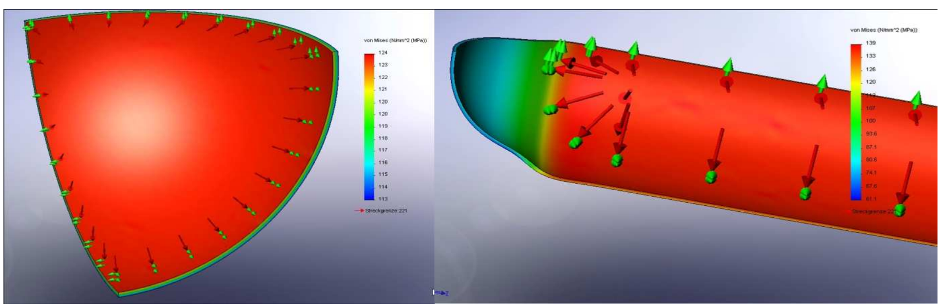


Figure 3. FEM analysis comparison of ball tank and bottle tank

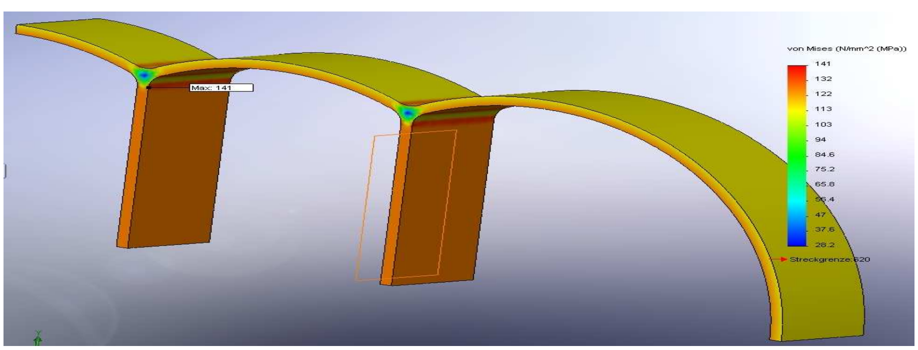


Figure 4. FEM Analysis from actual concept

Figure 5. Exploded View

Because the complex cross-sectional shape, conventional dished ends at the open profile ends would be very difficult if not impossible to manufacture and would have bad stress distribution, another form of cover was selected.

The two covers are made of relatively thick, solid material and then corresponding form-optimized pockets (Fig. 6) will be machined to achieve a uniform pressure distribution.

The resulting volumes are connected by separate corresponding holes between the individual pockets in order to create a jointly usable volume. Due to the massive construction of the cap, it is possible to integrate various functions directly and save space in the cap, such as safety and relief valves, pressure gauge and other necessary components.

The caps can be glued or welded, depending on the chosen mix of materials with the proper tank section. Furthermore, the two covers are connected by two cross-beams to be able to support the high forces generated by the pressure. Due to the massive caps and the two struts it is formed a stable security cage that protects the tank in the case of a crash situation.

Figure 6. Sectional View

3. Conclusions

The development of a highly efficient pressure vessel for liquid petroleum gas (LPG) in integral design was realized by authors.

By geometry variations and simulation parameters and with the help of FEM analysis was realized an optimized LPG tank for cars having a very good volume utilization efficiency of 80%.

Based on laborious work by authors, we managed an analytical expression of the phenomenon that occurs in damaged beams.

References

[1] V. Ignat, *Patents as source of information,* Modtech 2007, Iasi, ISBN 978-9975-45-034-8.

[2] P. Lorenz, *Fahrzeugsysteme*. HTWdS, 2.000.

[3] V. Ignat, *Patentrescherche*, HTWdS, 1997 / 1998.

[4] ****, Autogas*- Wikipedia, http://de.wikipedia.org/wiki/Autogas.

[5] ****, Verordnung über Druckbehälter, Druckgasbehälter und Füllanlagen (DruckbehV)* ,27.02.1980 , 21.4.1989, 23.6.1999.

[6] ****, DIN EN 13445*- Druckbehälterauslegung.

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