CNG CARS SAFETY IN ACCIDENTS (CASE STUDY:IRAN)

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ABSTRACT

In the last decade,air pollution has become a major problem in metropolises.Therefor using alternatives for common fuels, especially gasoline was ordered. In a country like Iran with the second biggest natural gas resources in the world, CNG was the most important choice.This potential led to vast manufacture and usage of CNG consuming automobiles. Being used in different climates and areas and because of the susceptibility of natural gas,these automobiles have always been vulnerable in accidents.
Based on the statistics from reliable sources and scientific methodes,this research tries to present the order of importance of CNG fuel system parts in accidents.The results of this reaserch will reveal the priority of making the system parts safe.

INTRODUCTION

After the prevalent manufacture and usage of bi-fuel engine aoutomobiles ,especially CNG consuming automobiles in the recent years, currently there are around 750000 automobiles of such kind in Iran.This puts Iran in the forth place among the countries using alternative fuels. The parts of the fuel systems of CNG automobiles are manufactured under strict standards and are installed on the automobiles both in factories and workshops. The information received from reliable sources shows flaws in different parts during the usage and in accidents. The results shows problems first in unprotected areas and then in the the assemblage of parts.
These problems have mostly occured with the systems which have been installed in workshops and caused incidents like fire or explosion.
Using the statistics of the parts damaged in accidents happened to CNG automobiles and analyzing them using Delphi method,this research presents the scientific ranking of the importance of securing and checking the parts.The results could be used in the process of writing and correction of the standards,as well as the manufacturing and installation.

RESEARCH METHOD

In order to have results most compatible to reality,this article tends to apply the CNG and car safety expert's opinions as well as group decision making to give the best possible picture of CNG system weak points.
This research is based on Delphi method,hence a brief explanation of this method is presented.
In the early 1950s a project known as Delphi was satarted by th U.S air force.The goal was to use the the experts opinions to estimate the number of Russian atomic bombs that can cause a certain damage in the USA technic called Delphi was used in this project.This technic aims to access the most reliable group agreement (of the expert`s opinoins) for an issue and it does through questioning the experts frequently and questionaires. Dephi method has three properties,impartial answers to the questions,repeated sending of the questionaire, and collecting and analysing the answers in groups.
The number of resendings varies between 3 to 5, and depends on the answerer's agreement and the additional information needed. The first questionaire usually needs answers to a major question while the other questionaires are based on the the answers to previous ones. Delphi process stops when a group agreement has been reached or sufficient exchange of information has been done.
Delphi method has 11 levels which are the followings:
1.Preparation of the questionaire
2.Choosing the expert group
3.Propounding the main question in the first questionaire
4.Analysys of the answers collected from questionaire no1
5.Preparation of the second questionaire based on the answers from questionaire
6.Analysys of the answers collected from questionaire no 2
7.Preparation of the third questionaire
8.Analysis of the third questionaire
9.Analysys of the answers collected from questionaire no3
10.Preparation of the final report of the Delphi process
11.Informing the questioned experts of the results

CASE STUDY

First the experts who are going to answer the questions are identified.This group consists of experts in CNG installation and safety who work in automobile factories,traffic police and etc.
The minimum number of experts is 10 to 15 ,suggested by Delphi method,which can be more if possible.In this research almost 20 experts opinions have been used.
In the next stage,the key question is prepared and the first questionaire is presented.In the first questionaire,we tend to expose the experts to the general information and then the details are presented to clarify the possible ambiguities.
In this questionaire the experts are asked to choose the most important parts of the CNG fuel system.These parts are the followings:
1. tank
2. steel pipes
3. tank valve
4. feeding valve
5. solenoid
6. safty valve
7. electrical circut wires
8. stepper
9. regulator
10. electronic control unit(ECU)
11. connection nut
12. mixer

After the important parts are identified,a questionaire called questionaire no2 is prepared.
In this stage experts have been asked to use their experience to give each of the parts a factor of importance between 1 and 12.
No 12 shows the most important part while no 1 is the least important one.
After the responses were analysed,the geometric averages of weighted index assiegned by the experts have been calculated.
The resultant numbers have been written in the tables of another questionaire and given to the experts.
Being informed about the averages of the numbers assigned by the other experts,each expert is able to delibarate and present the best possible value for the final weighted index.
The final index of importance for each part gained from questionaire 3 are given in table 1.

Table 1.
CNG system`s part final weighted index

element	tank	Steel pipes	stepper	Connection nut	safty valve	tank valve	solenoid	regulator	ECU	electrical circut wires	feeding valve	mixer
Final weighted index	2.47	9.18	4.75	7.03	7.52	4.09	5.60	5.47	3.87	3.91	4.45	3.54

After the factors are written down,it's time to make the pair comparison matrix, in which:

$$a_{ij} = \frac{1}{a_{ji}} \forall i, j = 1,2,3,..., n \qquad (1)$$

If the judgments are totally compatible and stable, they should:

$$a_{ik}.a_{kj} = a_{ij} \forall i, j, k = 1,2,3,..., n \qquad (2)$$

Because:

$$a_{ik}.a_{kj} = \frac{w_i.w_k}{w_k.w_j} = \frac{w_i}{w_j} = a_{ij} \forall i, j, k = 1,2,3,..., n \qquad (3)$$

Hence the inputs of this matrix are correct only when we have full satability and a_{ij} could be gained from equation 4.

$$\left(a_{ij} = \frac{w_i}{w_j} \right) \qquad (4)$$

In figure 1 the pair comparison matrix for prats of CNG system is presented.

Figure 1. Pair comparison matrix in related to CNG system`s

1.0000	0.2695	0.5205	0.3521	0.3290	0.6053	0.4417	0.4523	0.6387	0.6323	0.5567	0.6998
3.7101	1.0000	1.9313	1.3063	1.2207	2.2456	1.6388	1.6781	2.3696	2.3460	2.0653	2.5964
1.9211	0.5178	1.0000	0.6764	0.6321	1.1627	0.8486	0.8689	1.2269	1.2148	1.0694	1.3444
2.8402	0.7655	1.4785	1.0000	0.9345	1.7191	1.2546	1.2846	1.8140	1.7960	1.5811	1.9876
3.0392	0.8192	1.5820	1.0701	1.0000	1.8395	1.3425	1.3747	1.9411	1.9218	1.6918	2.1269
1.6522	0.4453	0.8600	0.5817	0.5436	1.0000	0.7298	0.7473	1.0552	1.0447	0.9197	1.1562
2.2639	0.6102	1.1784	0.7971	0.7449	1.3702	1.0000	1.0240	1.4459	1.4315	1.2602	1.5843
2.2109	0.5959	1.1509	0.7784	0.7275	1.3382	0.9766	1.0000	1.4121	1.3980	1.2307	1.5472
1.5657	0.4220	0.8150	0.5513	0.5152	0.9477	0.6916	0.7082	1.0000	0.9901	0.8716	1.0957
1.5814	0.4262	0.8232	0.5568	0.5203	0.9572	0.6985	0.7153	1.0100	1.0000	0.8803	1.1067
1.7964	0.4842	0.9351	0.6325	0.5911	1.0873	0.7935	0.8125	1.1473	1.1359	1.0000	1.2571
1.4290	0.3852	0.7438	0.5031	0.4702	0.8649	0.6312	0.6463	0.9126	0.9036	0.7955	1.0000

Now using Mathematica software,eigenvectors and eigenvalues for each of the part are attained,according to equation 5.

$$\text{Eigenvalues}[a] \qquad (5)$$

The eigenvectors and eigenvalues relative to the maximum eigenvalue(λ_{max}) are presnted in table 2

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Table 2.
Eigenvalues and eigenvectors of CNG system`s parts pair comparison matrix

	Normalized eigenvectors	eigenvectors	Eigenvalue
W_1	0.010874	0.1305	$\lambda_{max} = 12.000$
W_2	0.0403459	0.4842	-0.0000813388+0.000042003i
W_3	0.020891	0.2507	-0.0000813388-0.000042003i
W_4	0.03088625	0.3706	0.0000676155+0.0000414148i
W_5	0.03305	0.3966	0.0000676155-0.0000414148i
W_6	0.017967	0.2156	0.0000572791+0.0000220286i
W_7	0.024619	0.2954	0.0000572791-0.0000220286i
W_8	0.024043	0.2885	$-2.38002*10^{-6}$+0.0000466114i
W_9	0.017027	0.2043	$-2.38002*10^{-6}$-0.0000466114i
W_{10}	0.017197	0.2064	$-0.000022273+8.91057*10^{-6}$i
W_{11}	0.019535	0.2344	$-0.000022273-8.91057*10^{-6}$i
W_{12}	0.01554	0.1865	$4.02022*10^{-6}$

The normalized eigenvector for each criterion shows the order of importance of that criterion comparing to the other criteria. The results are presented in table 3.

Table3.
CNG system`s parts in order of importance

priority	part	final weighted index
1	Steel pipes	0.040346
2	Safety valve	0.033050
3	Connection nut	0.030886
4	solenoid	0.024619
5	regulator	0.024043
6	stepper	0.020891
7	Feeding valve	0.019535
8	tank valve	0.017967
9	electrical circut wires	0.017197
10	ECU	0.017027
11	Mixer	0.015540
12	tank	0.010874

CONCLUSION

In orther to specify the influence rate of each CNG system parts on automobile safty,a model was presented.To identify the important parts according to experts opinions feedback,a lot of repeated opinoions that could cause confusion or misleading have been omited. The results were reached through the process of accessing to priority criterias and identification of each part`s level of importance in accordance to Delphi method steps, are desireble and reliable.

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