Health monitoring of 4-wheeler from different noise levels

Manpreet Singh*, Rajeev Kumar*, Piyush Gulati*, Jaiinder preet Singh*, Sumit Shoor*, Hapreet Singh**

*School of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab-144411

**Department of Planning and Quality, Nettbuss AS, Oslo, Norway

Abstract

Sound levels are very crucial for an automobile because of strict norms framed by the government. Once the automobile has been sold to the customer then it's customer's duty to maintain its health otherwise the sound level of the automobile will grow up. The higher sound level will not only dangerous to the pedestrians but also a sign of fault arises in the main component of automobile. In this case study health of four different variants based on odometer reading for Maruti Suzuki swift diesel is studied on the bases of recorded sound levels. Mainly, sound levels for idle condition and moving condition were measured and discussed along with the feedback from owners or with the visible facts. It has been concluded that the proper servicing of the vehicle and tire condition plays very significant role in reducing the sound levels of the vehicle.

Introduction:

Sound pollution is term we often come across which is the propagation of disruptive noise in the environment causing a serious impact to the human. The main sources of this disruptive noise close to the human life can be estimated as the traffic noise or the vehicle noise [12]. Unfortunately, with less focus on that day by day conditions are becoming worst. This concern is not only lying with the manufacturer to manufacture a vehicle generating less noise but also to the consumers that how they are maintaining it. This is not only avoiding the detrimental effect on the humans but also it will enhance the life of the vehicle [1]. The five main sources of sound in an automobile are engine, transmission system, cooling system, exhaust system and tires [1,4]. When engine is turned on and in idle condition then engine sound, partial exhaust sound and partial transmission sound are the mainly contributes to the total sound [2-3]. Tires and exhaust system are contributing more sound when automobile is in running condition. Each part is having its own significance and reasons for generating sound [5-9]. The sound level of each part stays within the limit as long as its in a proper working condition but when it starts deteriorating or some fault initiates then the sound level increases due to harshness [10-14]. Even if the sound level of one-part increases then it affects the overall sound level of the automobile.

This study aims to estimate the health condition of four same four wheelers Maruti swift with different odometer readings. The sound levels of vehicles were recorded by using sound level meter for the idle and running conditions. All the recorded sound levels were compared for various conditions such as inside cabin and pass-by noise. On the basis of compared sound levels the estimations made were confirmed through visual inspection or feedback from the owner.

Description of selected vehicles:

The four selected cars of Maruti Suzuki Swift VDi (Diesel Engine) were categorized on the basis of their odometer readings. The Car 1 manufactured in year 2017 and driven for 34252 kms and last serviced at 25000 kms (estimation from the owner). The service gap describes the how many kms the vehicle was driven after its service. Similarly, other cars with the same data are presented in the Table1 and been designated as Car2, Car 3 and Car 4 on the basis of odometer reading.

Table1. Description of the cars tested

Swift VDi	*Odometer reading*	*Last service*	*Service gap*	*Manufacturing year*
Car 1	34252	25000	9252	2017
Car 2	59124	57000	2124	2016
Car 3	79478	72000	7478	2016
Car 4	101289	95000	6289	2014

Test results with discussion:

In the first set of experiment noise levels were recorded for the idle condition of the cars. The cars were set at a level of 2000 rpm to record the cabin noise with and without cooling system turning on. The recorded levels show that the car 2 is having the minimum sound level for both the cases inside the cabin. The sound level was also recorded after opening the bonnet by keeping the cooling system on and off by keeping the sound level meter at a distance of around one meter. In the case when cooling system was off the sound was recorded mainly for the engine and when cooling system was turned then noise level was recorded for the combined engine and cooling system. The recorded level of engine sound was subtracted from combined sound level of engine and cooling system on the logarithmic scale of decibel to find the cooling system sound. All the sound levels are presented in Table 2 and it can be observed that the Car 2 is recorded for the minimum sound level under idle conditions for all the cases. The Car 4 is also showing lower sound levels compared with other cars in the case of idle conditions. Table 3 represents the percentage of more sound level generated by other cars at the same condition in comparison to the minimum level. It can be observed that engine of Car 3 is making almost double sound than that of the minimum level and cooling system of Car 1 and Car 3 is making 3 times and 6 times more sound level than that of the minimum level respectively. In Car 3 there is something wrong with the cooling system and when contacted with the owner then we came across with the fact that lastly, he has serviced his cooling system when odometer reading was 25000 kms. The lower sound levels of Car 2 can be predicted because of the least service gap in kms.

Table2: Recorded sound levels for the idle conditions without loading

Conditions @2000 rpm	*Car 1*	*Car 2*	*Car 3*	*Car 4*
Cabin Noise	62.7	**60.9**	62.2	61.1

without AC				
Cabin Noise with AC	67.5	**65.6**	70.8	67.6
Engine Noise without AC	82.5	**81.9**	85.3	82.2
Engine Noise with AC	85.6	**83.1**	88.1	83.9
Cooling system noise	83.1	**76.9**	84.8	79

Table 3: Percentage of more sound level generate by other cars in comparison to the minimum level for the idle conditions

Conditions @2000 rpm	*Car 1*	*Car 2*	*Car 3*	*Car 4*
Cabin Noise without AC	51.35	0	34.89	4.71
Cabin Noise with AC	54.88	0	231	58.49
Engine Noise without AC	14.81	0	118.7	7.15
Engine Noise with AC	77.82	**0**	216.2	20.22
Cooling system noise	316.8	**0**	516.5	62.2

In the second set of experiments cars were made to run in the first gear and at 2000 rpm. The cabin sound levels were recorded by keeping the cooling system on and off. Also, by keeping the same set of conditions the pass-by sound levels were recorded by keeping the sound level meter at a distance of 3 meters. The recorded sound levels are presented in Table 4 along with percentage more sound level from the minimum reference sound level at the same condition in Table 5. From the noise levels it can be observed that cabin noise level is coming out to be highest for Car 3 for both the cases and pass-by noise level is coming out to be highest for Car 2. This means that apart from the cooling system problem Car 3 is also running through some acoustic leakage in the cabin. In Car 2 the pass-by noise level can be because of either exhaust system or because of tire sound. Upon visual inspection it can be observed that the tires in Car 3 are worn out and need to be replaced. In this contest the Car 4 is again showing good agreement in the sound levels without turning on cooling system.

Table4. Recorded sound levels for the running cars in 1^{st} gear with various conditions

Condition: 1^{st} gear @ 2000 rpm	*Car 1*	*Car 2*	*Car 3*	*Car 4*
Cabin Noise without AC	64.2	64.6	66.3	**63.7**
Cabin Noise with AC	**65.9**	68.2	71.7	67.5
Pass-By Noise without	70.7	73.1	69.2	**68.1**

AC				
Pass-By Noise with AC	72.7	77.0	**72.4**	73.1

Table 5: Percentage of more sound level generate by other cars in comparison to the minimum level for the running car in 1st gear

Condition: 1st gear @ 2000 rpm	*Car 1*	*Car 2*	*Car 3*	*Car 4*
Cabin Noise without AC	12.2	23	81.97	0
Cabin Noise with AC	0	69.82	280	44.54
Pass-By Noise without AC	81.97	216.22	28.82	0
Pass-By Noise with AC	7.15	188.40	0	17.49

In the third set of experiments cars were made to run in the second gear and at 2000 rpm. The cabin sound levels were recorded by keeping the cooling system on and off. Also, by keeping the same set of conditions the pass-by sound levels were recorded by keeping the sound level meter 3 meters apart. The recorded sound levels are presented in Table 6 along with percentage more sound level from the minimum reference sound level at the same condition in Table 7. In higher gear ratio Car 1 is having minimum sound level inside the cabin and Car 4 is again showing good agreement. In the feedback from the owners of the cars it has been identified that owner of Car 4 has serviced his vehicle in the right time as compared to the casual approach shown by other owners. Again Car 2 is showing maximum sound level for the pass-by noise and the reason was earlier identified as worn out tires.

Table 6. Recorded sound levels for the running cars in 2nd gear with various conditions

Condition: 2nd gear @ 2000 rpm	*Car 1*	*Car 2*	*Car 3*	*Car 4*
Cabin Noise without AC	**66.2**	70.5	69.1	68.3
Cabin Noise with AC	**68.1**	68.9	72.5	69.3
Pass-By Noise without AC	73.9	77.2	**72.3**	74.8
Pass-By Noise with AC	*74.9*	77.6	76.5	**73.7**

Table7: Percentage of more sound level generate by other cars in comparison to the minimum level for the running car in 2nd gear

Condition: 2nd gear @ 2000	*Car 1*	*Car 2*	*Car 3*	*Car 4*

rpm				
Cabin Noise without AC	0	169.0	94.98	62.18
Cabin Noise with AC	0	20.22	175.4	31.82
Pass-By Noise without AC	44.54	246.73	0	77.8
Pass-By Noise with AC	31.81	145.47	90.54	0

The sound levels of Car 1 to Car 4 are drawn in graphs and shown in Figure 1 to Figure 4 respectively. It can be observed that the cabin noise is coming out to be highest for the condition when cars were running in the 2nd gear and at 2000 rpm. And for the same running condition pass-by noise is also recorded to be maximum. The reason for the maximum sound level is that the higher loading conditions excites parts of the engine more turbulently and therefore generates higher level of sound.

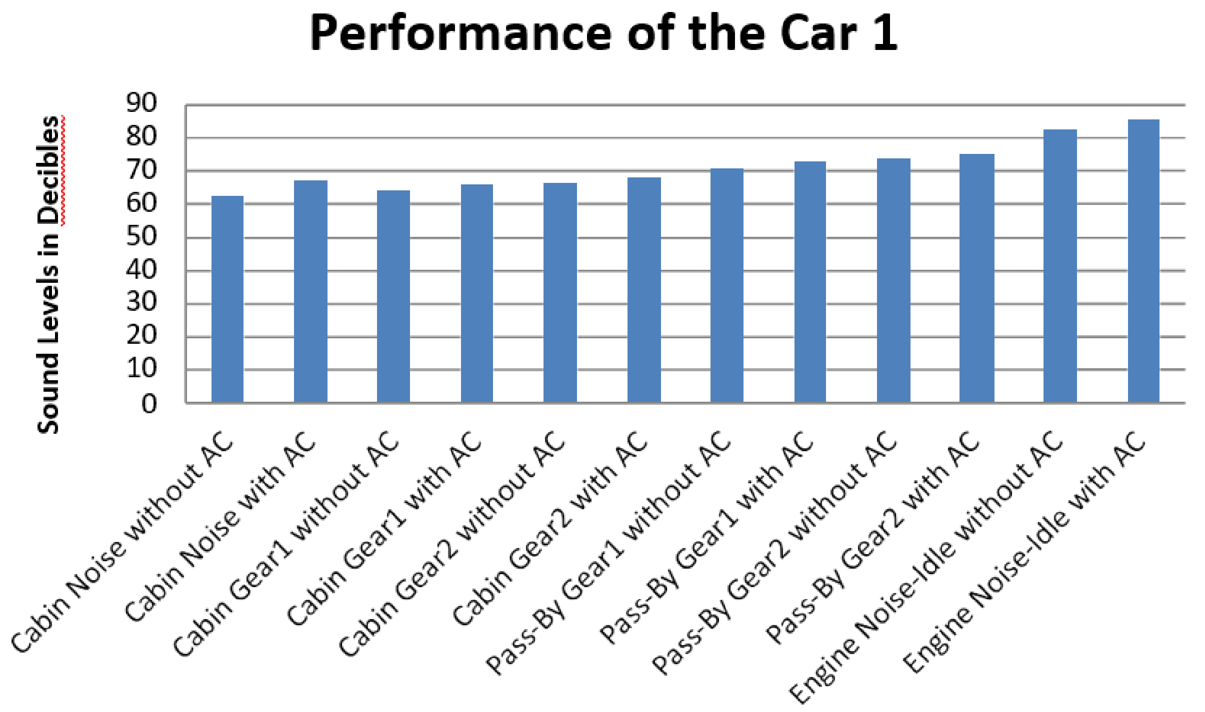

Figure 1: Sound level of Car 1 for all the conditions

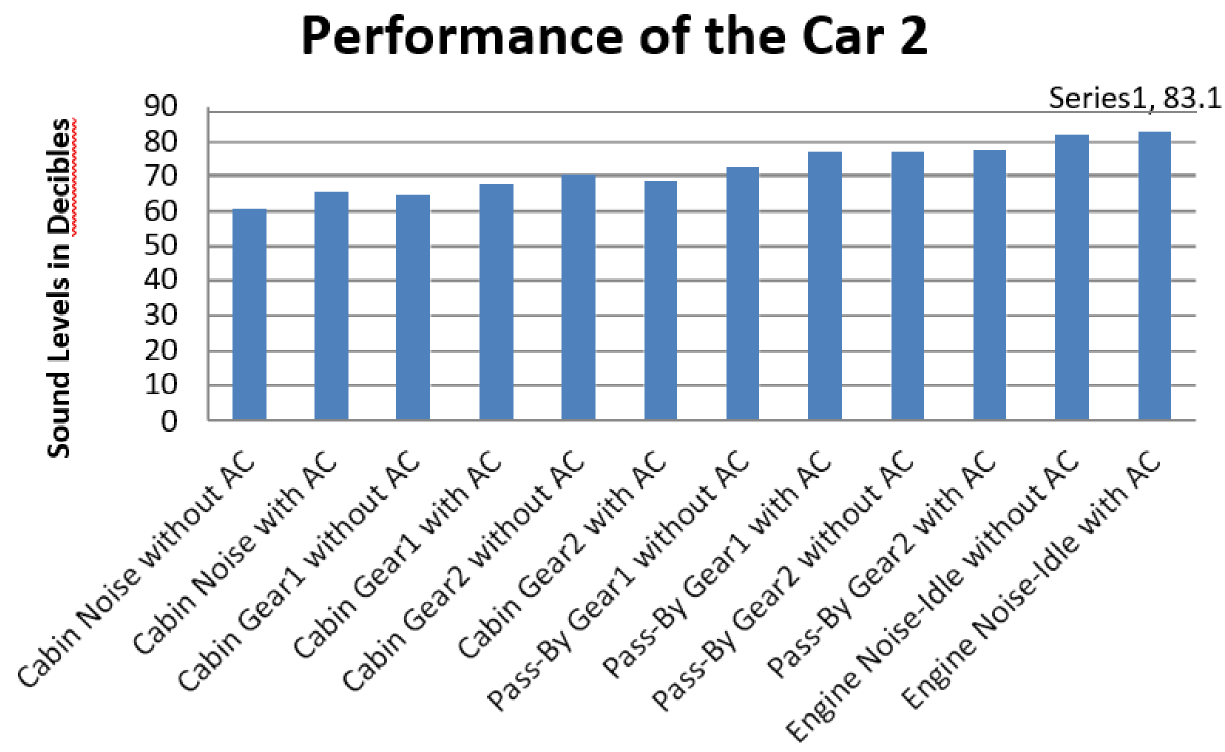

Figure 2: Sound level of Car 2 for all the conditions

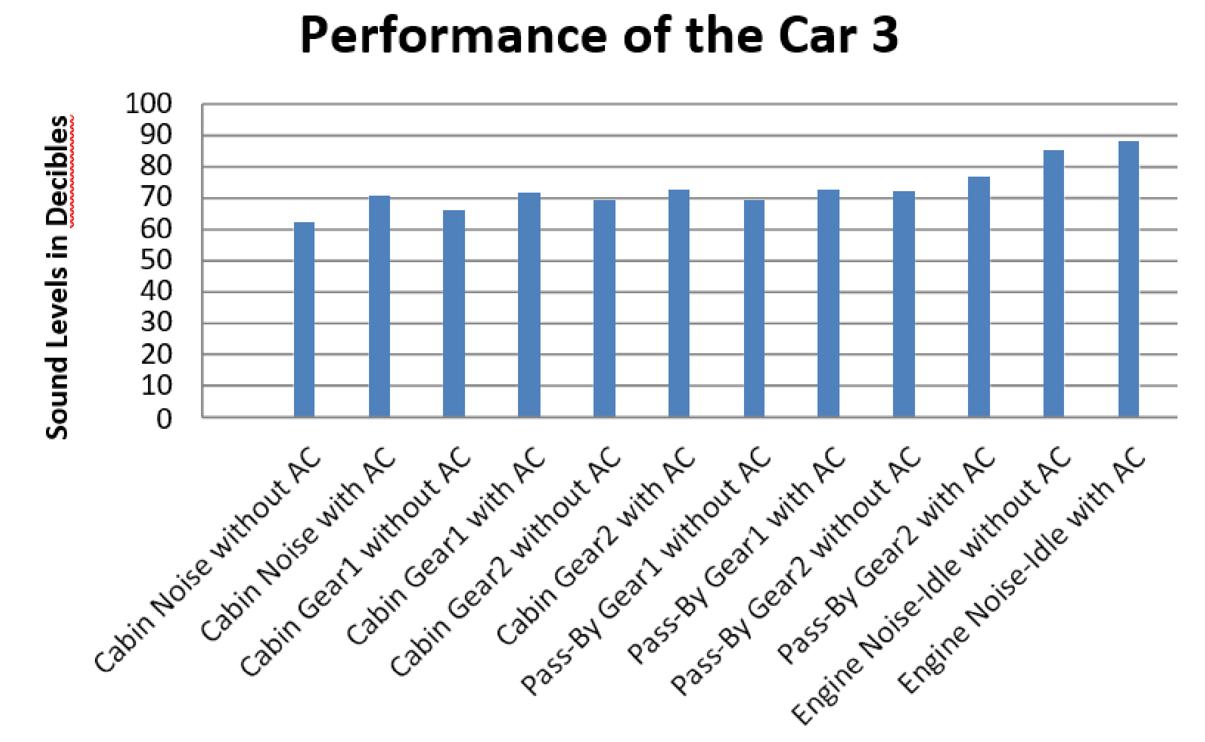

Figure 3: Sound level of Car 3 for all the conditions

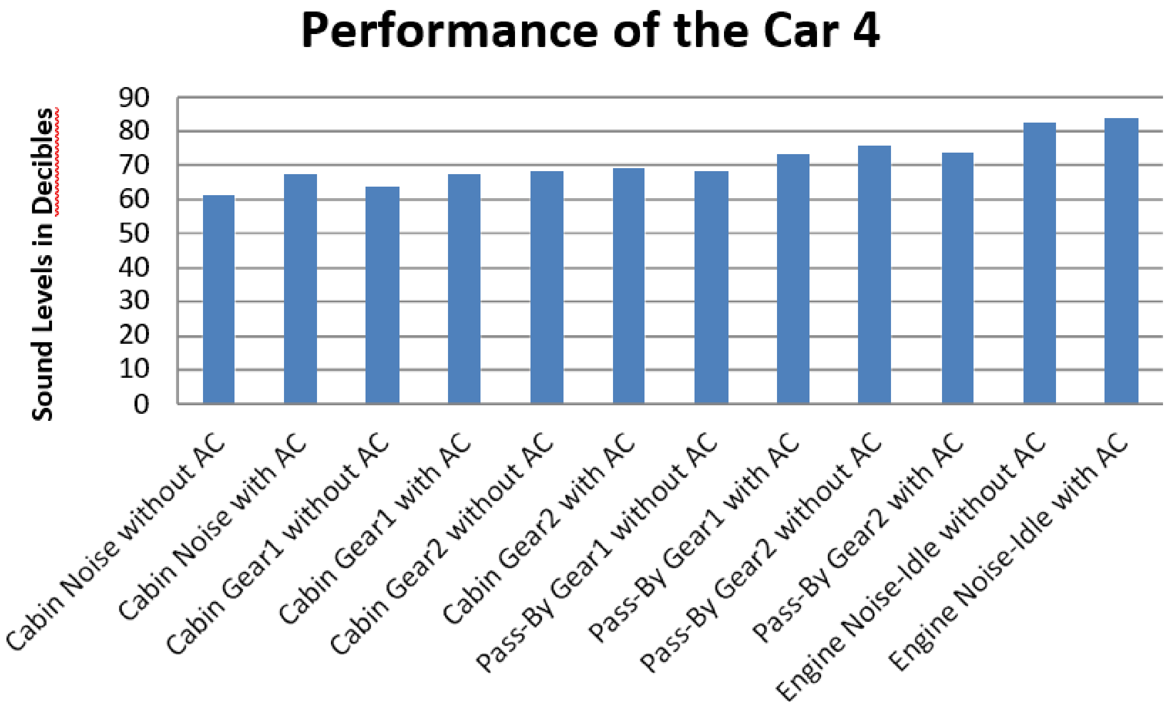

Figure 4: Sound level of Car 4 for all the conditions

Conclusion:

The case study done on the Maruti swift cars has helped in drawing the following conclusion

1. The service gap has great impact on the engine and cooling system noise as Car 2 which was recently serviced compared to the other cars and has significantly low levels of sound level in the idle conditions.
2. The cooling system problem can be identified by simply recording the sound levels at idle conditions. In Car 3 the problem of cooling system was identified due to higher sound level and during verification it has been identified that the cooling system was not serviced for a long time.
3. The worn-out tires produce more sound compared to the normal tires and it can be identified from the recorded pass-by noise level. Also tire noise is having very little impact in the cabin as in Car 2 there is no impact of worn-out tires can be recorded in the cabin.
4. To keep the car in the good shape it is recommended to get vehicle serviced as prescribed by the manufacturer. In feedback analysis the Car 4 has shown remarkable levels of sound even after driven for more than 100000 kms just because of strict regime followed by his owner for the service.
5. Under loading conditions vehicles are producing more sound as in all the cases maximum sound level was recorded for the second gear and at 2000 rpm.

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