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Customer Irritancy on Break Air Compressor Assembly Noise Reduction from Intermediate Commercial Vehicle by test-based Method

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ABSTRACT

This vehicle level Project deals with the Functional Image of the vehicle is as important as & other factors of the vehicle. Noise and Vibrations is one of the important parameters in Functional Image. Customer can be irritated with unwanted sounds from the vehicle. One such problem is identified, Break Air Compressor noise from Intermediate commercial vehicles. Metallic Noise Originates from gear Train, Rattling of The Gears Between Idler and Compressor Gear and or Idler and Crankshaft Gear, Gear Hammering noise. based on subjective and objective analysis with irritant noise source identification has been done. As per Idler gear contact ratio improvement modification result shows the best acoustic performance as vehicle level as well as engine test bed level with help of test-based measurement analysis.

Keywords— Air compressor, Compressor Gear, Intermediate Commercial Vehicle, Source identifications

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I. INTRODUCTION

The function of the air compressor is to provide and maintain air under pressure to operate devices in air brake systems an air compressor .Compressed air is air kept under a pressure that is greater than atmospheric pressure. The compressor is driven by the vehicle's engine and functions continuously while the engine is in operation. Compressor gets input power from Engine through gear train. This power is used to rotate the single cylinder slider crank mechanism. Sound quality requirements have been more often used in light and heavy-duty trucks market. Then, vehicle owners felt uncomfortable with rattle noise mainly at idle speed with air compressor operating in load phase. (1) Diesel Engine Air Compressor Rattle Noise Georges Vre tos Glyniadakis, Alexandre Bercelos de Souza Where Air is compressed to the desired pressure. Current torque is share for 10 bar pressure. Compressed Air is filled into Tank with given capacity. Currently 60 litres. Compressor is getting input as torque at the compressor end. active torque on gear Compressor load pressure at the compressor is controlled by valvetrain changes sign once every crankshaft rotation, due to Single cylinder slider is moved by cam shaft. Metallic noise originates from gear train, rattling of the gears between idler and compressor gear.

II. PROBLEM STATEMENT

An objectionable impulsive noise is observed during compressor pressure build up from 6 bar to 10 bar The Compressor noise is perceived significantly & Complained about higher noise in Intermediate Commercial Vehicle vehicle. Air compressor metallic noise observed at idling while Air compressor is loaded. Noise intensity is more above 6 bar tank pressure. Noise not observed when the air pressure is relieved from tank at 10 bar.

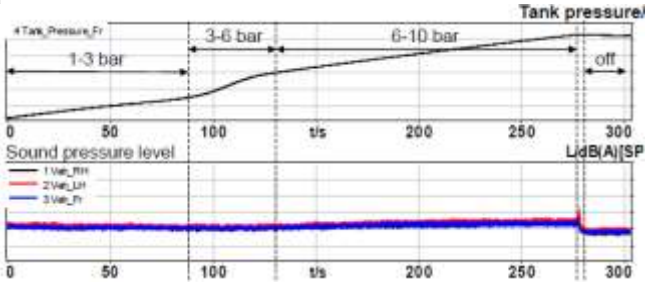

Fig:1 Sound Pressure level at near field noise

Fig shows that while filling air pressure in tank Similarly sound pressure level increase and after cut off Noise not observed when the air pressure is relieved from tank at 10 bar Pressure.

III. OBJECTIVE OF STUDY

1)Understanding of Brake air noise problem from customer point of view.

2) Define source path receiver model for this type of noise.

3) Confirmation of solution on engine test bed level as well as on vehicle level.

4) Jury level confirmation for Acceptance.

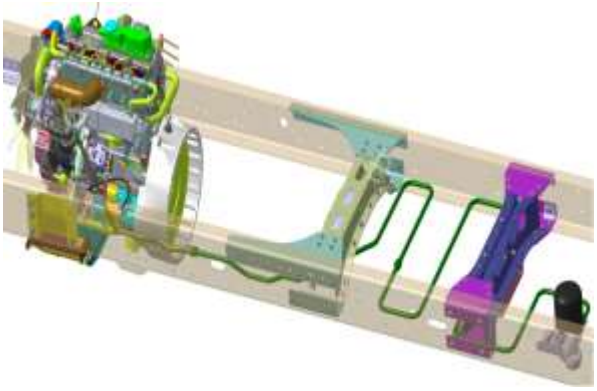

Fig:2 Engine to Compressor tank Cad Layout Model

IV. METHODOLOGY

Phase 1	Baseline Measurements on Vehicle level
Phase 2	Source Identification on vehicle level
Phase 3	Path Level Modifications on Vehicle level
Phase 4	Engine test bed iterations with test results
Phase 5	Final Validation with results
Phase 6	Result and Discussion
Phase 7	Conclusion

Table:1 Methodology used for resolved compressor noise reduction.

V. MEASUREMENT TEST SETUP

Measurement was performed at vehicle level at low idle condition as well as engine bed at low idle level. Noise has been measured at at near compressor location, 1m from compressor, Driver location and Vibration had been measured at compressor head, body, FIP connected to compressor.

Phase 1: Baseline Measurements on Vehicle level
With Compressor Noise Vs without Compressor Noise

With Compressor Noise Vs Structural Vibration Comparison.

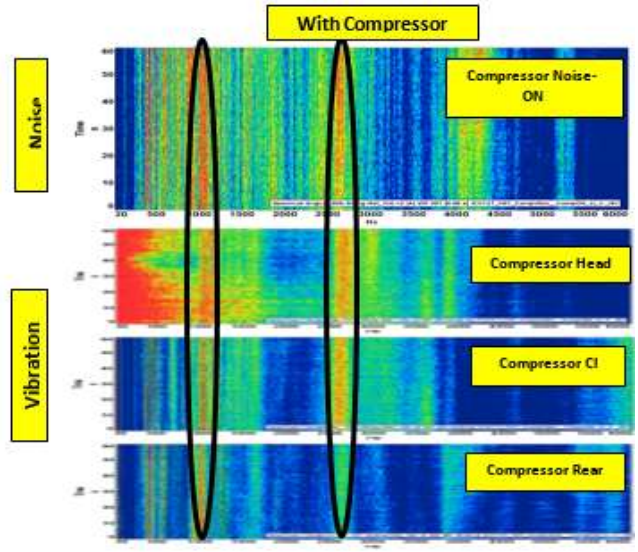

Fig:3 Result and Graphs: Compressor Noise Vs Structural Vibration Comparison with Compressor noise

Fig no3 shows the Strong Correlation of the dominant Frequency of 1070 Hz and 2460 Hz with vibrations levels on Compressor components. The same dominant frequencies contribution is significantly reduced after the compressor cut-off.

Without Compressor Noise Vs Structural Vibration Comparison

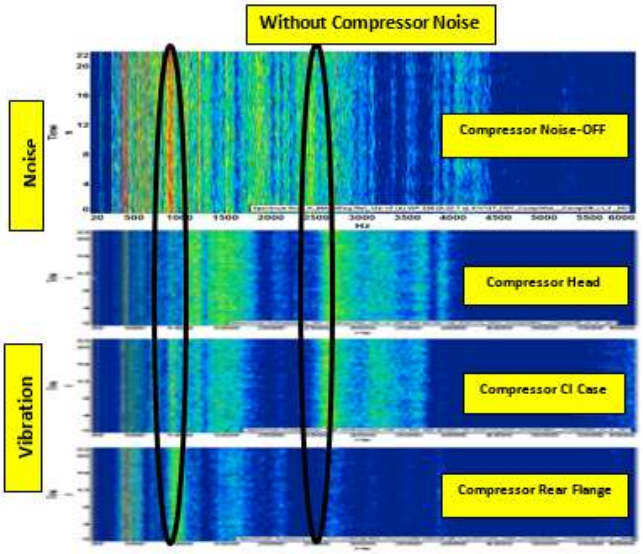

Fig 4 Compressor Noise Vs Structural Vibration Comparison Without Compressor Noise

Fig no 4 shows that There is no strong Correlation of the dominant Frequency of 1070 Hz and 2460 Hz with vibrations levels Compressor components. The same dominant frequencies not replicating on compressor off Conditions.

Phase 2 Source Identification

When the gear train is replaced by a belt drive, the torque

fluctuations will be captured by the belt. As a result, the metallic rattling noise is eliminated. The gear train mechanism is used for driving the compressor gear mounted on compressor shaft and idler gear. Belt drive is used instead of gear train to run the engine by using the belt drive the noise of compress get reduced by 5 dBA, Detail analysis can be shown in figure change in drive makes unwanted noise get reduced in the high frequency zone.

Fig:5 Idle gear that is removed when compressor is driven by belt change in drive makes unwanted noise get reduced

Fig:6 Compressor is driven by belt drive

Fig no 6 shows that Belt drive is used instead of gear train to run the engine by using the belt drive fluctuations will be captured by the belt. As a result, the metallic rattling noise is eliminated. The gear train mechanism is used for driving the compressor gear mounted on compressor shaft and idler gear. Belt drive is used instead of gear train to run the engine by using the belt drive the noise of compress get reduced by 5 dBA, Detail analysis can be shown in figure change in drive makes unwanted noise get reduced in the high frequency zone. Noise amplitude was higher while with air compressor noise is on conditions at Compressor gear. compressor head, Compressor CI case and Compressor rear. It clears that there is contribution from gear train drive Noise amplitude was negligible while with air compressor noise is on conditions at belt drive conditions. Form above test measurement observed all problematic frequency has been vanished.

Phase 3 Path Level Modifications

Abnormal noise is perceived during air compressor operation and is not observed when pressure in outlet pipe is released. Structural modifications:

1) Reducing reservoir tank cut off pressure to 8 & 6 bar while no effect on noise although there is a reduction in dynamic pressure fluctuation.

2) Increasing reservoir tank capacity from 40 to 60 liter there is no effect on noise although there is a reduction in dynamic pressure fluctuation.

3) Pressure fluctuations measured on inlet and outlet of compressor in order to understand the effect of fluctuations on noise.

4) Effect of adding 40-liter resonator tank in outlet pipe then also no effect on noise although there is reduction in dynamic pressure fluctuation

5) Effect of using rubber hoses of varying length (4m & 5.5 m) still no effect on noise although there is a reduction in dynamic pressure fluctuation

6) Idler gear added 3 mm washer and lifted from original position as we get significance improvement on hammering noise.

Fig:7 Rubber Hoses and Auxiliary tank

Fig:7 Explain on that Effect of outlet pressure level and tank capacity, Reservoir tank cut off pressure 10,8 & 6 and tank capacity 40/60 litre with 6 bar cut of pressure.Pressure fluctuations measured on inlet and outlet of compressor in order to understand the effect of fluctuations on noise. And Effect of using rubber hoses of varying length (4m & 5.5 m) There will not be significance improvement on compressor noise reduction.

Reservoir tank cut off pressure(bar)	Po (Peak to peak)	Pi	Po/Pi	Noise at compressor unit dB(A)
10	0.83	0.03	27	89.77
8	0.73	0.03	24	89.87
6	0.76	0.03	25.33	89.95
Tank capacity (liter) @ 6 bar cut off	Po (Peak to peak)	Pi (Peak to peak)	Po/Pi	Noise at compressor unit dB(A)
40	0.76	0.03	25.33	89.95
60	0.67	0.03	25.33	89.29

Table: 2 Test Iterations Results on path level modifications

Table no 2 shows that all path level modifications are not helping to resolved compressor noise reduction.

Phase 4 Engine test bed set up with trials results

Fig:8 Compressor noise engine test bed Measurement

Fig shows the Compressor noise engine test bed Measurement test set up.

Fig: 9 Compressor Brake System dryer with Acoustic covered

Fig shows that Compressor brake system dryer with help of acoustic pack covered while during compressor phasing and Fuel injection pump phasing.

Iteration 1 Compressor Phasing with 30,60,90,120,150 Degree

Baseline Vs Compressor Phasing 90 Degree

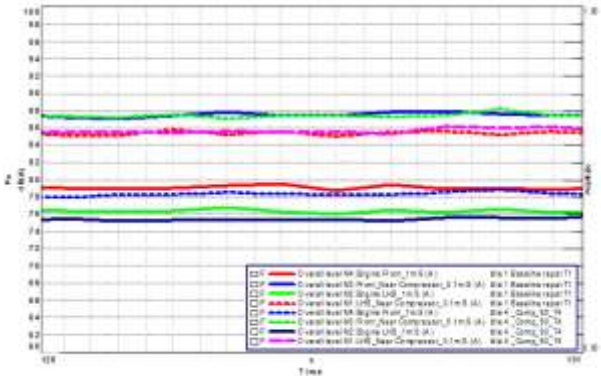

Fig:10 Baseline vs compressor phasing at 90 degree

With respective changing the compressor phasing angle how the compressor noise behaviour changing that understood. After the compressor Phasing, we haven't gotten the significance improvements. After all the compressor phasing, we came to know these trails not helpful to resolved compressor noise reduction.

Iteration 2 FIP Phasing with 60, 90, 150 and 67.5 Degree

Fig:11 Fuel Injection Pump Phasing Keyway

Baseline Vs FIP 67.5 Degree

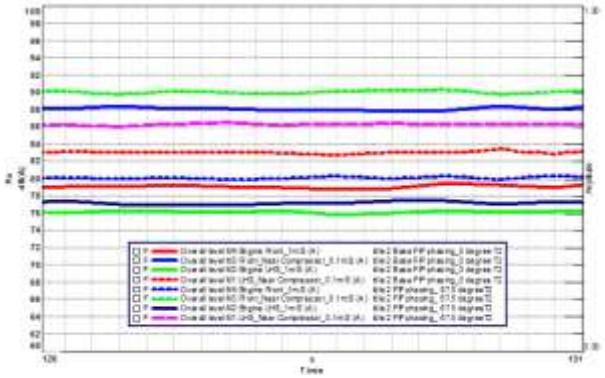

Fig :12 Baseline Vs Fuel Injection Pump phasing 67.5 Degree

With respective changing the Fuel injection Pump phasing angle how the compressor noise behaviour changing that understood. After the Fuel injection Pump Phasing, we haven't gotten the significance improvements. After all the compressor phasing, we came to know these trails not helpful to resolved compressor noise reduction.

Iteration 3: Idler gear contact ratio improvement

Baseline Current Idler and compressor gear having 3mm gap

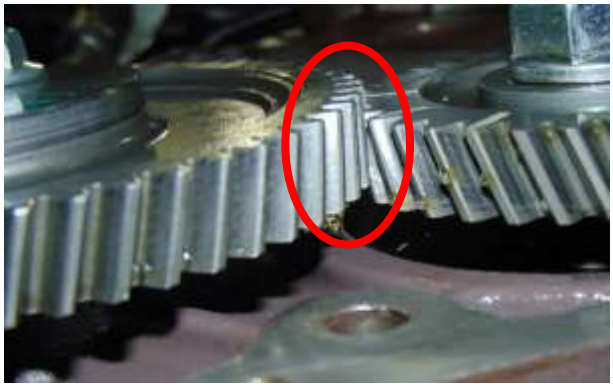

Fig:11 Baseline idler gear position on engine

With lifted idler gear and Filled gap with 3mm with washer

Fig:12 Modified idler gear position on engine

Based on the root cause identification, gear train drive had been diagnosed as root cause of the noise source from compressor. To find the exact reason of noise, extensive noise, linear vibration and angular vibration data had been captured. Idler gear modification shows the best acoustic performance.

We got the significant improvement on compressor noise reduction from idler gear adding 3mm washer almost 5 dB (A**)**

Phase 5: Final Validation with results

Torsional acceleration -Idler gear
Comparison between baseline and idler gear modification
Baseline Vs Idler Gear Lifted measurement test result

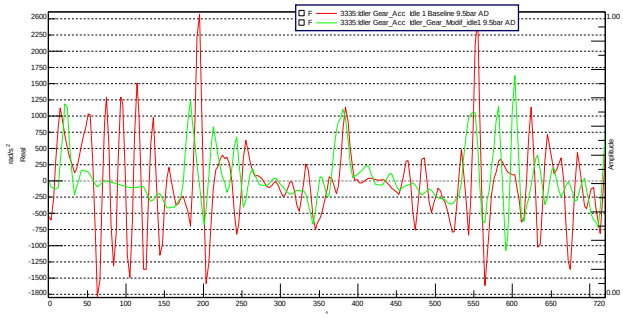

Fig:13 Baseline Vs Idler gear lifted Torsional acceleration - Idler gear measurement test results.

Fig shows that red curve peak is baseline idler gear result which shows high amplitude level which can create high frequency noise. Green curve shows that modified lifted idler gear level which can see high amplitude peak disappeared after modified idler gear.

Phase 6: Result and Discussion
1)After recording time domain data, software itself will convert that data into frequency domain data and results will be displayed in form of colour plot. After getting all Plots data analyzed to get the correct information about compressor noise problems and Problematic frequency.

2)Compressor body stiffening and inlet outlet pipe isolation there will not be effect on Noise Reducing reservoir tank cut off pressure to 8 & 6 bar, no effect on Noise although there is a reduction in dynamic pressure fluctuation.

3)Increasing reservoir tank capacity from 40 to 60 liter still there is no effect on Noise although there is a reduction in dynamic pressure fluctuation., Pressure fluctuations measured on inlet and outlet of compressor in order to understand the effect of fluctuations on noise.

4)Effect of using rubber hoses of varying length (4m & 5.5 m), No effect on noise although there is a reduction in dynamic pressure fluctuation., From sound quality analysis, it is evident that the annoying noise is predominant between 500 & 1700 Hz at driver ear and 1m location from compressor.

5)As per Idler gear contact ratio improvement result shows the best acoustic performance as vehicle level as well as engine test bed level.

6)We got the significant improvement on compressor noise reduction from idler gear adding 3mm washer almost 5 dB (A**)**

Phase 7: Conclusions

1)In this Report, test based measurements were performed to find the root cause of the noise from brake air compressor assembly.

2)Test results showed the compressor driving gear train as root cause Intermittent noise generated by compressor assembly was identified during subjective evaluation.

3)Result from analysis study on similar noise issues Due to high cyclic torque fluctuation of both compressor and FIP in the gear train, the current gear train layout is strongly susceptible for generation of gear hammering noise

4)This validates the source of compressor noise and vibration is rattle hit by compressor gear on idle gear due to load on compressor gear.

5)Measurement was performed at vehicle level at low idle condition as well as engine bed at low idle level. We gotten significances improvement on compressor noise reduction. from idler gear adding 3mm washer almost 5 dB (A**)**

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