Case study on Carbon Fiber spring suspension for FORD ENDEVOUR THUNDER+

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Abstract:

Most of the SUV's (sports utility vehicles) available today, more so in the Indian market, are over-designed, especially at the chassis and suspension level. This is either done to account for the type of usage and road conditions or simply to extend the factor of safety and product life. However, there are some categories of these SUV's that are more of ON-Road type and are less meant for OFF-Road usage, in this case the suspension and chassis are either left with their original design (in case of CKD or CBU) which are some way designed to the road / usage conditions of the country of its origin.

The present case study is focused on quantifying the vibration and shock response using the existing (default) metal leaf springs and then by replacing them with carbon fiber springs made by M/s ARC INDUSTRIES-Ichalkaranji (Maharashtra, INDIA). *A variety of road conditions were used to assess the change in the vibration response.*

1.0 Introduction

In the classification of personal utility vehicles, there are mainly two categories, namely

- Vehicles like "cars" built for smoothness, styling and overall drive and ride comfort
- Vehicles like "Sports Utility Vehicles", with better build quality, ruggedness and improved road handling.

The trade-off between the two are straight and simple; the former is more good for city and highway drive and the later more preferred for off-road and all terrain usage. Given this, the built-up of the vehicle also matters greatly in-terms of engine power, design of chassis, suspension, type and size of tires and so on. Considerations for smooth drive, ride and comfort are inadvertently compromised in case of a SUV owing its basic need of build quality to handle increased loads, roads and terrains. The suspensions in particular, will play a major role in the overall design and thus be a part of the overall compromise in terms of ride comfort.

In effect, the SUV's suffer from higher impact loads, vibration and shock as transferred from road conditions; the degree of magnitudes may vary on the SUV variants and makes, but the fact remains that they are nowhere comparable to the type of comfort achieved in the car class of vehicles, *what is the compromise in car category is a different issue altogether.*

The present case study is taken up on one such SUV vehicle; the latest in the Ford range, the Endeavour Thunder+, the task is a simple, straight forward comparison of transfer functions of vibration loads below and above the rear-spring mountings. The following testing conditions were consolidated for testing both the default metal leaf springs and the replacement carbon fiber springs.

2.0 Measurement Conditions / Setup and Instrumentation

- A typical all mix road condition about 11 km were selected; the terrain has combination of gravel stretch, humps and bumps, soft asphalted road and finally some stretch of muddy uneven road.
- Approach speeds at select road humps varying between 40 to 80kmph.
- Mid-gear continuous run on uneven mud terrain.
- Acceleration / Deceleration on flat asphalted road in the range of 100km (up/down)
- Two tri-axial accelerometers, one mounted on the cross bar of the rear wheel (on differential dome) and the second with the certified seat adaptor (for whole body vibration) on the mid-road of the passenger seating. Both of them connected to Mobile Data acquisition system for real time recording of vibration data.

Pictures of Set-up and Preparation

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Pictures of change over to Carbon-Fibre springs

3.0 Measurements and Results

The vibration acceleration data from 2 tri-axial accelerometers were continuously recorded for the 11 km stretch of testing (both with the metal and carbon springs); the measured data were post processed for two parameters

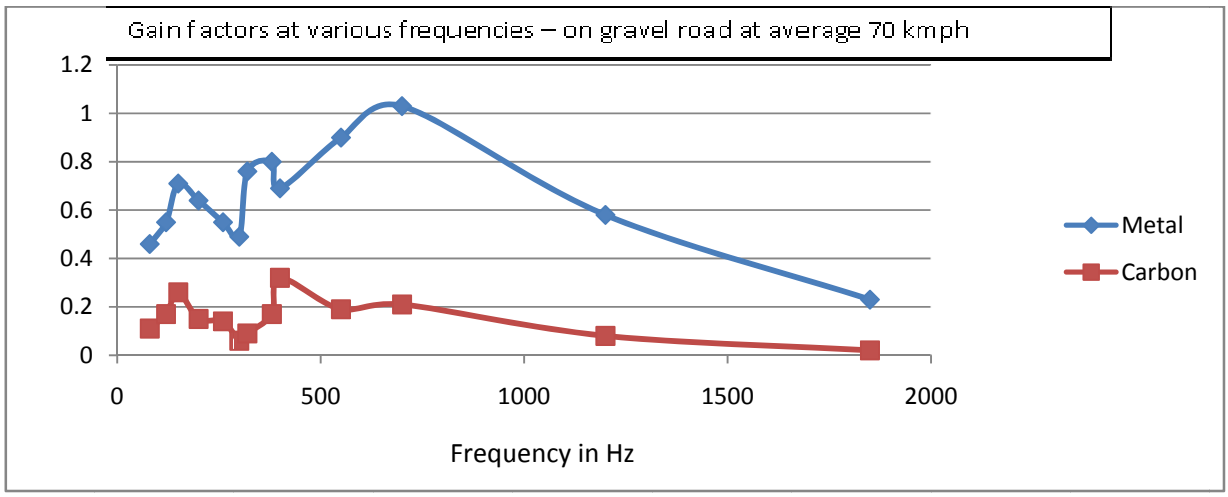
1. Absolute acceleration values “g” at specific time events; this is related to vehicle speed & specific road condition; the conditions are repeated for both the type of springs.
2. Transfer function values between the reference (below springs) and the response accelerometers (on the seat) to characterize the effect of the spring performance.
3. The vehicle had the same loading conditions all through the test; 5 adults + driver were occupying the seating area.

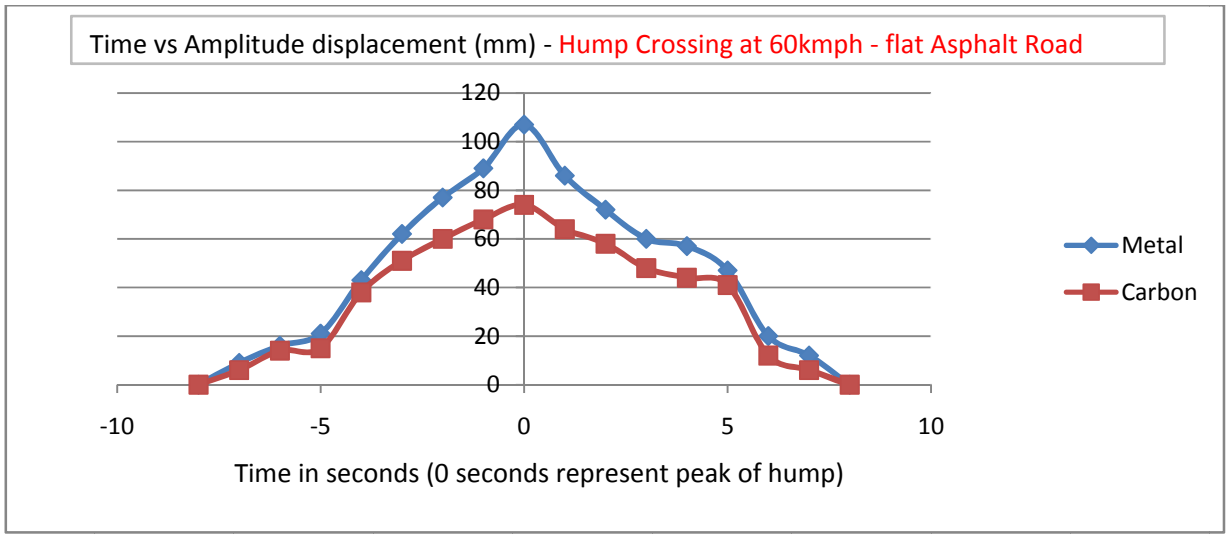
Table below puts across direct comparison of Acceleration “g” values for a certain set of condition common for both the type of springs

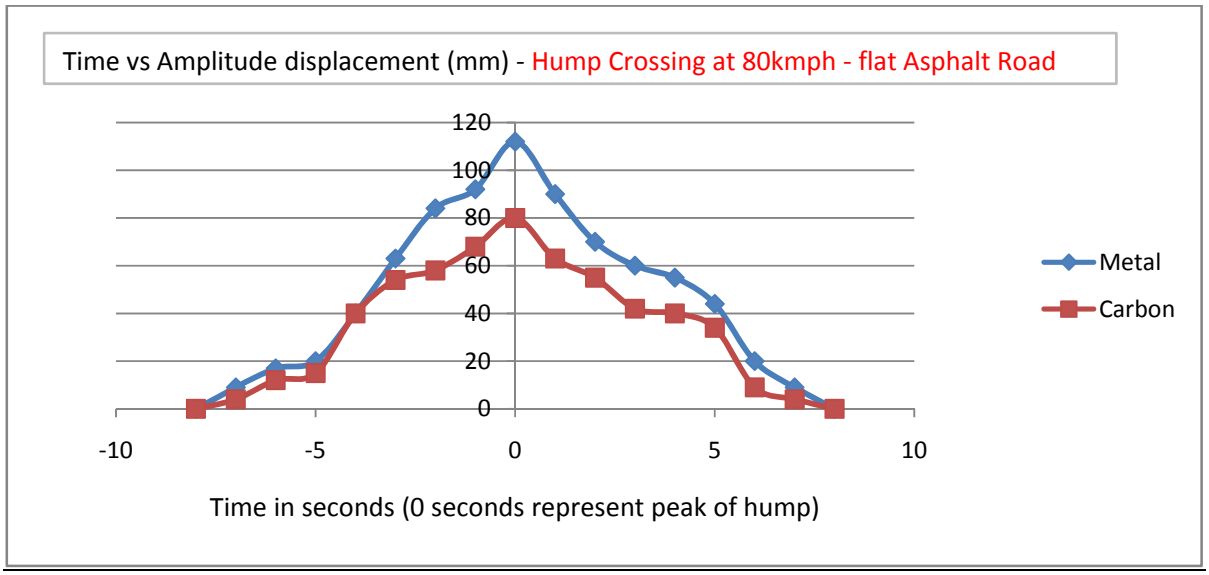
Measurement /Road Condition	Acceleration value in "g"* at seat location (+z direction)		Remarks
	Metal spring	Fibre spring	
60km to 20km deceleration – flat asphalt road – Hump Crossing, braking distance 15 meters	1.82	0,42	
100km to 30km deceleration – flat asphalt road – rumble crossing, braking distance 34 meters	2.11	0.51	Average of 5 rumblings
Gravel road continuous vibration at 70 km speed	1.52	0.41	Averaged value
Reversing 8 meter distance 20 kmph	0.47	0.13	

* Predominant frequency instantaneous vibration (can be referred to shock)

4.0 Test Graphs







5.0 Conclusions and Remarks

- The factory fit metal leaf springs are rigid and offer higher dynamic force transfers through their structure and finally to the seating area of the vehicle; this could be a default constraint of using the metal springs as the design considerations of the vehicle define the spring usage and its overall build-up.
- The middle and rear seating areas are most affected by the vibration and shock transfer through the rear spring sets; as the length of the overhang of the chassis over the fulcrum point of rear wheel directly defines the amplification factor of displacement, the rigid connections offered by the metal spring does contribute to the overall comfort feel in the cabin seating area.
- In contrast, the carbon fiber spring offers a overall improved performance in attenuating the input shocks to a great extent; a factor of 4 times reduction in observed in most of the predominant frequencies that were considered for the tests.
- The carbon fiber spring sets offer a higher degree of vertical direction deflection, while this is a small concern in terms of static deformation, the overall reduction in dynamic displacements combined with increased vibration damping rations offer superior ride comfort.
- As the metal springs are in a stacked set, relative lateral motion tend to create quirk noise over time, this is completely overcome in case of single blade carbon spring.
- Static deformation in metal springs is a known phenomenon, while this factor is almost negligible in case of carbon springs tested.
- The overall longitivity of the tested carbon springs are yet to be proved as the samples tested are for limited period of time.