

Effect of Force Vectoring Spring implementation into a Twistbeam Rear Suspension

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ABSTRACT

A twistbeam is a very cost effective rear suspension architecture which has drawbacks compared to an independent rear suspension. One drawback is the lateral compliance during cornering compromising the handling of the vehicle. Common solutions to correct this issue are complex reinforcements or an additional Watts linkage. However, these solutions drive high cost and additional weight. The challenge was to find a solution which reduces the gap to the functional performance of a multilink rear suspension. Due to the bush attachment, the set-up of a twistbeam is always a compromise between ride comfort and vehicle dynamics. The more comfort is desired the softer the bushings will be, resulting in less agility and slower vehicle response. The target was to determine a way to separate ride comfort and dynamic agility. A solution was found using a special set of springs working as a dynamic anti-compliance mechanism. The so-called force vectoring springs are designed in a way, that they create a lateral force component by their coil shape inclination. At the Ford K&C rig a significant reduction of toe compliance was shown and subjective drive evaluations confirmed the vehicle dynamics improvement.

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INTRODUCTION

A twistbeam suspension is a semi-independent suspension. It comprises two stiff longitudinal members that are connected via bushings to the vehicle body and a transverse metal beam connecting the two longitudinal members (Figure 1). The architectural advantage of a twistbeam compared to a multilink is the efficient package enabling an increased cargo volume. Furthermore, it is weight efficient and cost effective.

For parallel wheel movement, the twistbeam longitudinal members rotate around the front bushings (Figure 2). In this way, the suspension behaves like a trailing link suspension with no change of track and camber. For opposed wheel movement during cornering the suspension behaves like a semi-trailing arm suspension [1]. The wheel rotates around the virtual axis defined by the front pivot and the shear center of the transverse beam.

A twistbeam has disadvantages with regard to the dynamics and comfort performance compared to an independent suspension. One of the drawbacks of a twistbeam suspension is the location of the bushings. They are lower than the wheel center and therefore the wheel moves forward in jounce (Figure 2). This so-called kinematic precession is undesirable for good impact harshness. Moving the bushing upwards is usually impossible, as it would be in conflict with the vehicle siderail structure. To get a decent level of impact smoothness the bushings should be soft.

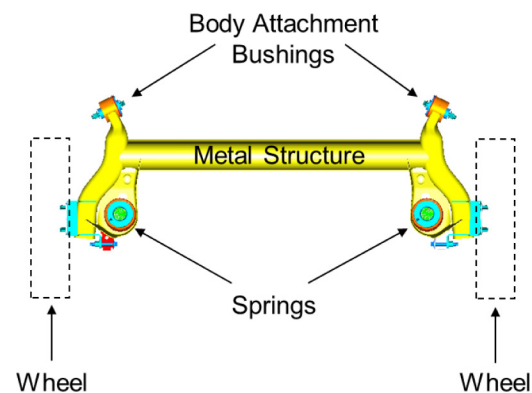


Figure 1. Twistbeam Architecture

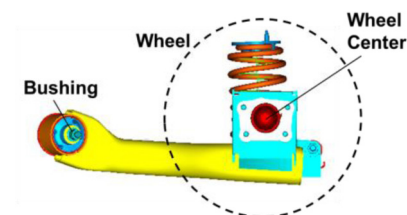


Figure 2. Twistbeam Side View

Another drawback of a twistbeam suspension is the behavior during side loads, especially during cornering. The lateral loads translate and rotate the whole axle due to lateral compliance in the front bushings and due to structural compliance of the twistbeam metal structure. The rotation causes an unwanted toe-out movement which implies an oversteer effect (Figure 3). The combination of relatively high lateral compliance and a certain level of lateral compliance oversteer causes some limitations to the steering and handling performance of a twistbeam suspension.

Common solutions to correct this issue are complex reinforcements or an additional Watt's linkage (Figure 4). However, such measures drive additional costs and can generate other issues such as weight increase and NVH degradation.

Another solution to improve the toe-out effect is to incline the bushing attachment to the vehicle body in the top view. Under lateral load (red arrow in Figure 5) the corner outer side moves up and the corner inner side moves down. This rotation of the twistbeam reduces the toe-out movement, but the actuation of this effect has to be paid by additional lateral compliances, making the vehicle less agile.

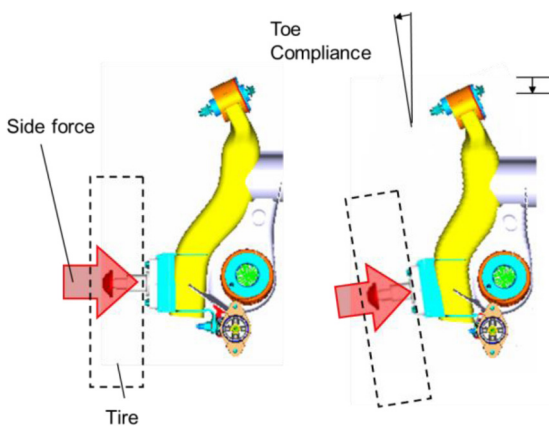


Figure 3. Toe-Compliance

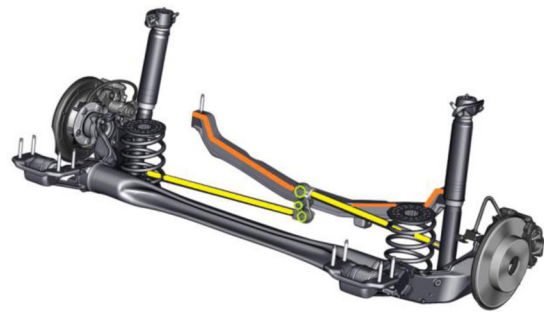


Figure 4. Watts Linkage at Twistbeam

Due to the attachment by bushings, the set-up of a twistbeam is always a compromise between ride comfort and dynamic lag. The more comfort is desired, the softer the bushings will be, resulting in less agility and slower response. The desired solution has to find a way to separate ride comfort and dynamic agility without sacrificing comfort for agility.

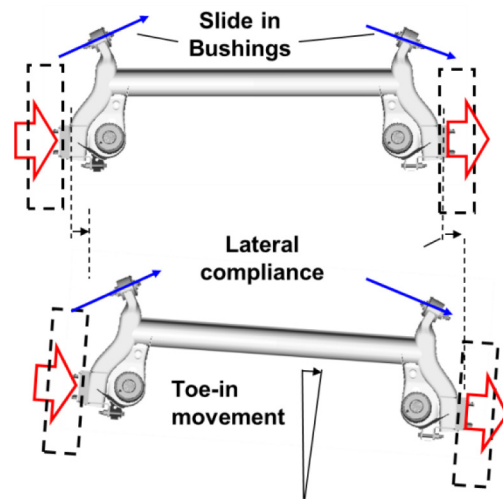


Figure 5. Inclined Bushings

The challenge was to find a solution which reduces the gap to the functional performance of an independent rear suspension. Furthermore, the solution should be easy to install and to replace. A modularity approach fitting into each program and the use of existing parts was desired.

MECHANISM EXPLANATION

The innovation consists of two main ideas that nobody has used so far. The first innovation is to incline the force vectors of the rear springs in a way that the lateral force coming from the inclination pushes in outboard direction at the attachment point of the spring to the twistbeam.

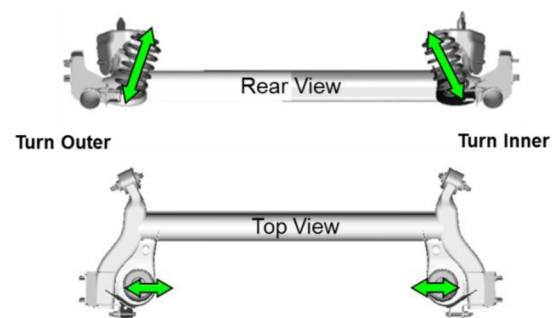


Figure 6. Spring vectors at straight ahead

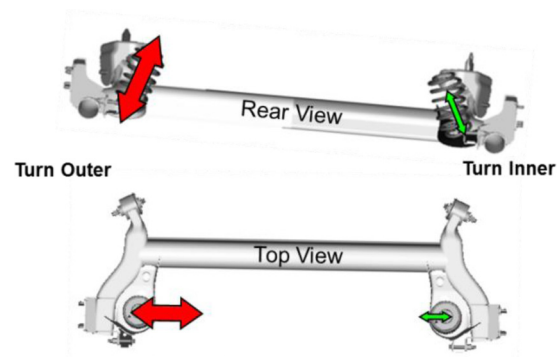


Figure 7. Spring vectors during cornering

