Advantages of a Level Vehicle

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1. Background

Traditional coil or leaf spring suspensions compress when cargo is added to the vehicle. As more cargo is added, the car or truck squats lower and lower. Since cargo is usually added to a pickup bed, or car trunk, the rear end usually squats much lower than the front end. This results in a "squashed", overloaded appearance. This looks silly, and there are many technical reasons why this is an undesirable condition.

2. Spring rate automatically adjusts to cargo

2.1 Description of Problem

It should not be surprising that small, lightweight cars should have soft springs, and large construction equipment should have beefy, stiff springs. But what about pickup trucks? These vehicles can operate with no cargo at all (no weight in the bed), or with thousands of pounds of cargo positioned over the rear axle. Ideally, the leaf spring of a pickup should adjust between soft (no cargo), or stiff (maximum cargo). Unfortunately, traditional leaf or coil springs are only sized for one loading condition, so the pickup has either good ride but can't carry much, or can carry a substantial cargo but with a severe ride penalty.

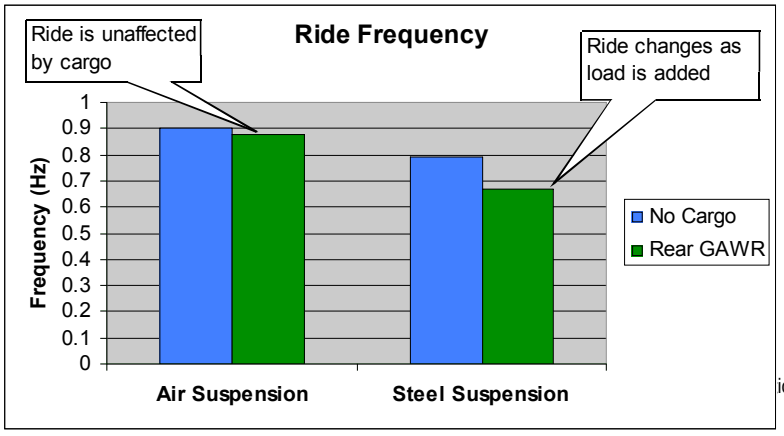
2.2 Improvement due to Air Suspension

One commonly accepted method of determining how the spring is sized to the cargo is to calculate the ride frequency of the vehicle body. For simplicity, we will neglect the tire stiffness. The ride frequency of the vehicle body can be approximated by the equation,

$$\omega_n = \sqrt{\frac{Spring\_rate}{Supported\_weight}}$$

As cargo is added to the vehicle, the supported weight increases. On a coil suspension vehicle, this results in a reduction in ride frequency, which is perceived as a "floating, uncontrolled" ride.

The behavior of an air suspension vehicle is somewhat different. As cargo is added, more air is added the spring to maintain ride height. This additional air pressure causes an increase in spring rate. The increase



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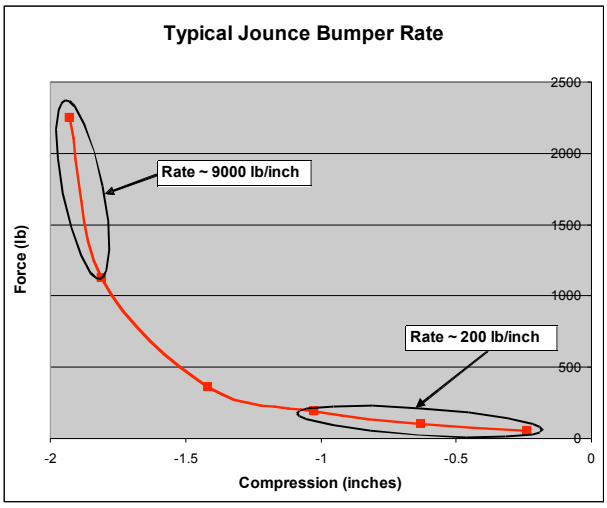
in spring rate closely matches the increase in supported weight. Thus, air spring systems provide similar ride characteristics for loaded and unloaded conditions.

3. Improved Clearance to Jounce Bumper

3.1 Description of problem



Loading a vehicle to GVW conditions often reduces ride height to the extent that no clearance remains between jounce bumper (bump stop) and the suspension member. In other words, *adding cargo "uses up available wheel travel".*

Jounce bumpers are typically designed with a highly progressive load-deflection curve. In other words, they start out soft, but very quickly become very, very stiff ! The jounce bumper shown in the attached plot, when fully compressed, is approximately 20 times as stiff as the vehicle suspension spring. How do you think this vehicle rides when it is fully loaded and the wheel hits a bump?

3.2 Improvement due to Air Suspension

FSIP air suspension systems are engineered to provide load leveling, either by manual additional of air, or automatic leveling provided by the Intelliride system. Vehicle ride height is maintained, regardless of cargo. Thus, sufficient clearance to jounce bumper (wheel travel) is ensured, which greatly improves ride.

4. Wheel and Driveline Alignment

4.1 Description of Problem

As cargo is added to a leaf or coil suspension vehicle, the suspension compresses and ride height is reduced. This will cause driveline angles (u-joint or cv-joint) to change, which can increase wear of these parts, or possibly induce unwanted vibrations.

If the vehicle is equipped with independent suspension, adding cargo will change wheel toe, camber, and caster. This can cause tire wear problems, and possibly affect steering and handling.

4.2 Improvement due to Air Suspension

Air suspension vehicles resist changes in alignment by load leveling. When cargo is added to the vehicle, additional air can be added to bring the vehicle back to original design height. At this height, suspension and driveline alignments should be at the correct setting.