All about air suspension systems

By John Kimpel, Division Marketing Manager, Firestone Industrial Products

Besides providing vibration isolation, air springs offer many other user-friendly advantages over the traditional leaf and coil springs. There are two basic types of air springs used in vehicle suspensions: reversible sleeve and convoluted. Regardless of whether an air spring is a reversible sleeve or convoluted style, it will operate on the same principle: A column of gas confined within a container allows it to use the contained pressure to generate force.

In the case of air springs, the gas is air and the container is a sealed fabric-reinforced rubber bellow or sleeve. Similar to a ball inflated with air, the load an air spring will carry depends on its diameter and therefore, the area of the column of air supported and the pressure of air inside it. The two basic relationships used in determining the load-carrying capability of an air spring are:

$$force = pressure \times area \qquad (1)$$

$$area = \pi \times \frac{diameter^2}{4}$$

The relationships above demonstrate that increasing the load an air spring can carry (the force) can be accomplished by increasing the pressure inside the air spring, increasing the diameter of the air spring (and therefore increasing the area) or both. The ability to change the load-carrying capacity simply by changing the air pressure, rather than changing out the spring, is a major advantage air springs have over steel.

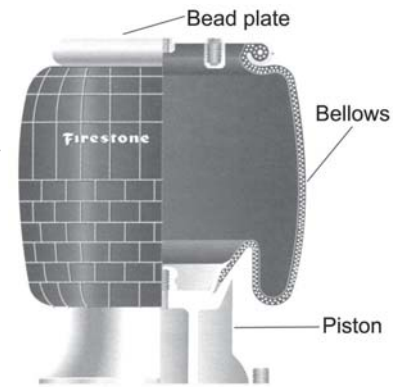
Because an air spring consists of a closed volume of air, the compression of the air spring (jounce travel) will cause an increase in pressure, while the extension of the air spring (rebound travel) will cause a decrease in pressure. This allows the air spring to have an automatic tendency to return to the neutral (design) height as it experiences disturbances in the driving surface.

The dynamic build-up in compression also helps protect against "bottoming out" and can be further increased on the reversible sleeve air spring by the addition of a "flare" at the bottom of the piston.

Components

Although the basic principles behind both the reversible sleeve and convoluted air springs are the same, there are some subtle differences between them. Most notably, the reversible sleeve air spring has a piston which is an additional component that the convoluted air spring does not have. The piston is the component that is fastened to the moving trailing arm or axle mount and, as a result, plunges in and out of the air cavity within the rubber bellows.

In general, a piston gives the reversible sleeve air spring an advantage over the convoluted air spring in that spring, rates can be further tuned using a variety of piston profiles. For straight-sided pistons, the reversible sleeve air spring has an advantage over the convoluted air spring, in that a constant load for a given internal pressure may be



maintained over a range of heights.

The two other major components of an air spring are the bead plate(s) and the fabric-reinforced rubber bellows or sleeve. The bead plate allows for a rigid attachment to the mounting surface(s) and the bellow is the dynamically functioning suspension component which contains the air.

The main advantages of an air spring over its steel leaf and coil counterparts are variable load-carrying capability, adjustable spring rate, user-friendly height control, low friction action, and road-friendly suspension increasing the pavement life.

As already mentioned, the load an air spring carries can be adjusted over a wide range, without changing the air spring height, simply by changing the air pressure. Traditional steel springs need to be replaced if the height must be maintained.

In addition to changing the load-carrying capability, a change in air pressure will also afford the benefit of changing the spring rate without changing the height and without a significant change in the natural frequency. Steel springs exhibit one spring rate for a given height and, once again, will need to be replaced if the height must be maintained.

Using air pressure from the compressor, the air spring height can be maintained by a closed-loop control system or adjusted to the other desired heights. This allows for "load leveling" and "squatting" capabilities that steel springs cannot offer.

Because there is a flexible rubber member separating the rigid attachment points to the frame and suspension, there is freedom to move about all six degrees of freedom without the resistance and squeaks experienced by the rigid interactions characteristic of steel leaf and coil springs.

Road-friendly suspension

In 1993 a study called the "Dynamic Interaction between Vehicles and Infrastructure Experiment" (DIVINE) was initiated by the Directorate of Science, Technology and Industry of the OECD. Interim results from the study were presented in 1995 and the final report in 1997.

The purpose of the study was to quantify the benefits of heavy vehicles with air suspension on roads. The knowledge gained and appreciated by the co-operating countries can be shared with countries that are rapidly expanding their transportation infrastructures. The end result is a faster payback and reduced costs of maintaining these infrastructures.

This study was conducted with participation from European and North American countries, as well as public and private institutions. The purpose of the study was to provide scientific evidence of the effects of heavy vehicles and their suspensions on road systems. Almost 50 per cent of road maintenance costs are associated with effects from heavy vehicles. Further, the amount of dynamic load exerting on roads is directly associated with the type of vehicle suspension.

Air suspensions increase pavement life by 15-60 per cent. This corresponds to increased static load of 4-12 per cent. A 15 per cent increase in vehicle mass limit can save upwards of $500 million per annum, while increased pavement life ensures significant reduction in road maintenance cost which forms 90 per cent of the annual road budget in OECD countries.

"Road-friendly" suspensions have low spring stiffness and coulomb friction with optimum damping. Well-designed air suspensions best meet these criteria.

For a complete copy of the DIVINE report, visit www.oecd.org.

Air suspensions are used on a vast majority of heavy duty vehicles in North America and Europe, with a growing penetration worldwide. The advantages of air suspension with regard to the vehicle, driver and transportation systems are appreciated in both qualitative and financial terms.

Firestone Industrial Products Company, LLC, a subsidiary of Bridgestone Firestone Diversified Products (BFDP), specializes in air spring manufacturing and technology with a history of more than 60 years of research and development of technologically advanced air springs.

With headquarters in Indianapolis, Ind., and six manufacturing plants located on four different continents, the company produces suspension products enhancing the driving experience for drivers of heavy truck/trailer, buses, rail vehicles, passenger cars, SUVs, light trucks, minivans, vans and motor homes.

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