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Optimizing A Vehicle's Suspension System and Overall Performance

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Abstract
The automotive industry heavily relies on the analysis of suspension systems to ensure user comfort and satisfaction. The commonly used coil spring suspension systems, while applicable in almost all vehicle designs, have limitations that need to be addressed. Industries rely on the longevity of their suspension systems to ensure vehicles work as required. Several factors influence the condition and performance of a coil spring system but the leaf spring system has fewer hindrances. The leaf spring suspension system can be a good alternative for wide-scale employment of suspension systems provided it is backed with certain adjustments such as a helper spring system for heavier vehicles. This paper uses finite element-based analysis simulations from OnScale and information from European Springs and ScienceDirect.

Introduction:
The effect of terrain and prolonged durations of driving have been extensively studied for automobiles. This is partly due to the industrial revolution where vehicles became heavily incorporated into society as a means to deliver goods and services and partly due to how centralized vehicles have become in daily transportation. Traditionally, many researchers and investigators in automobile companies have turned to personal experiences and human data to understand how comfortable rides have been or how effective certain vehicles have been in doing their job of transportation. As technology was not very advanced, stress and force were not tested on car parts in the same manner as they are now which led to expected discomfort in rough terrain. Fast forward to the 1970s when car manufacturers increased the space between the tires and the car body which allowed the shock absorbers to compress and expand more (Ireland Made). Automobiles then became more usable for transporting goods and services and carrying people for longer durations of time as they were now more comfortable. The terrain, however, in certain places still caused an issue. The effect of rocky or muddy terrains had not been studied to the significance they are now and this caused delays in transportation due to cars breaking down or goods falling off due to the heavy turbulence. In recent years, researchers and automobile developers have taken great importance in understanding variables, not just terrain, and their impacts on suspension systems. The importance of suspension systems ranges from automobiles to aircrafts in the aviation industry. Suspension systems also help keep the movement of the automobile in control by preventing excess movement. Excessive suspension with too much contraction and expansion may result in shocks causing wheels to get misaligned or parts of the automobile to break. Suspension systems also heavily impact the smoothness and comfort of rides which is very important in the current day and age of transportation where automobiles are the main means of transportation globally as they have become commercialized.

Due to the significance of suspension systems on automobiles, knowledge of factors and variables affecting the performance and effectiveness of suspension systems can be used to develop more effective suspension systems. It will play a very important role in not just the automotive industry but also the aviation industry and they are very significant portions of a country’s GDP. for example, the automotive and aviation industries together make up 7.1% of the global GDP (Aviation Benefits). This makes sense considering over 1.5 billion people use cars (Motor Biscuit) and 4.3 billion passengers use airplanes annually (ICAO). While there has been heavy R&D on

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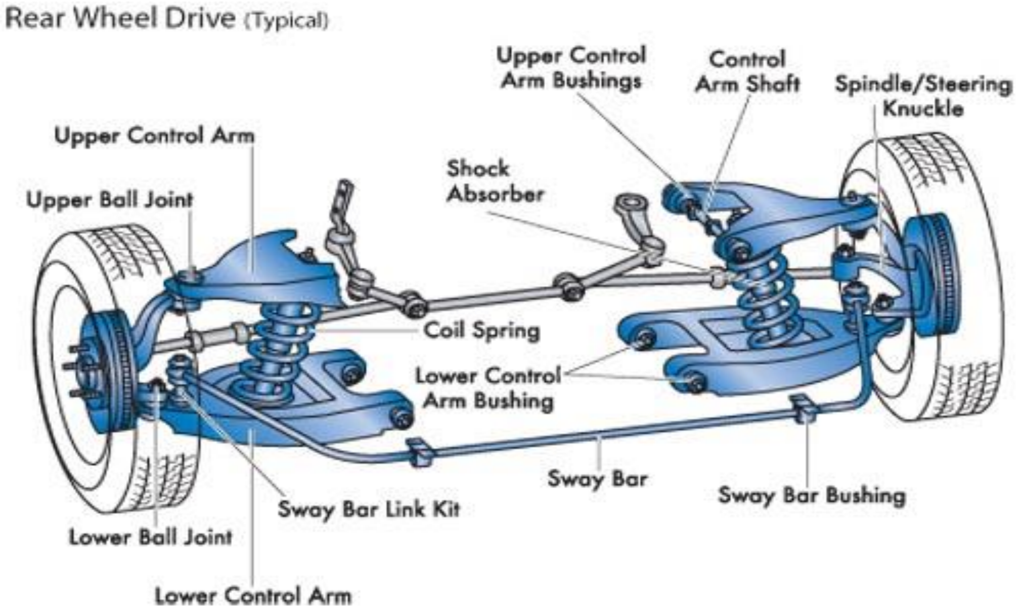
automotive vehicles, it has been a concern of how effective these suspension systems are over longer durations of time as well as in different climates and what happens to these vehicles when they are placed in different environments. This is specifically the case with off-road vehicles or vehicles in developing countries or with transportation vehicles such as lorries and trucks that need to travel large distances to different environments. Aviation and drones are attempting to replace this means of transportation; however, these new alternatives have not been successfully implemented. Suspension systems are still required in drones, etc as they are still used for landing and can be bothered by colder temperatures in higher altitudes, higher wind speeds, or coming in contact with birds. This makes studying and understanding suspension systems and the variables that affect them more important because as long as the vehicle operates, a suspension system is required.

What is a suspension system and how does it work?
A suspension system is an integral component of a vehicle that provides support, stability, and controlled motion between the vehicle's body and its wheels. It plays a critical role in ensuring optimal tire contact with the road surface, absorbing shocks, and maintaining passenger comfort. A well-designed suspension system enhances vehicle handling, stability, and overall performance. The suspension system consists of various interconnected components that work together to achieve these objectives. There are several parts of a suspension system as seen below.



(Lamech)

Coil Springs: Coil springs act as a means to store and release energy in response to vertical forces and road irregularities. When a vehicle encounter bumps or uneven road surfaces, the coil spring absorbs the impact energy by compressing or extending (Monroe). This protects the vehicle's chassis and passengers from excessive vibrations and shocks. The coil spring's elasticity allows it to return to its original shape after compression or extension, exerting a force to counterbalance the weight of the vehicle. This force ensures that the tires maintain optimal contact (tire contact patch of about 25 inches^2) with the road surface, promoting better traction, stability, and control (LousCarCare). A coil spring's characteristics such as its stiffness or spring rate significantly influence the suspension system's performance. The spring rate is the amount of force required to compress or extend the spring by a certain distance (Nmm^{-1}). A higher spring rate indicates a stiffer spring, while a lower spring rate corresponds to a softer spring. The choice of spring rate depends on factors such as the vehicle's weight, intended use, desired ride comfort, and handling characteristics (Penske). The spring rate can be determined by the material which is usually hardened steel. Coil springs can be designed and tuned to achieve specific objectives in

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suspension systems. For example, in a passenger car (1,900kg), the coil springs are typically designed to provide a balance between comfort and handling (European Springs). The springs should be soft enough to absorb road shocks and vibrations which helps provide smoother rides for the passengers. Simultaneously, they should be firm enough to prevent excessive body roll during cornering to maintain stability. This is dependent on the thickness (2.40mm-63.50mm) and the number of coils in the spring (6-12) (CoilingTech). In high-performance or off-road vehicles, coil springs with higher spring rates are used to handle increased loads, maintain ground clearance, and provide better handling characteristics. Adjustable coil springs are also used in some suspension systems, allowing the stiffness to be adjusted to suit different driving conditions or personal preferences.

Dampers (Shock Absorbers): Shock absorbers' main functions are to dampen and control the movement of the suspension system. When a vehicle encounters bumps or uneven surfaces, springs compress or extend to absorb the impact, however, without shock absorbers, the suspension system would continue to oscillate and bounce due to the stored energy in the springs. This would result in uncomfortable rides for the passengers, reduced tire traction, and compromised handling, making the ride unsafe (CarSales). Shock absorbers' work is done by converting the mechanical energy of the suspension system's oscillations into heat energy, which is then dissipated (NYU). This is achieved through hydraulic or gas-damping mechanisms. Hydraulic Damping systems contain a piston that moves within a cylinder filled with hydraulic fluid. When the suspension system oscillates, the piston is driven through the fluid, generating resistance. This resistance slows down the movement of the suspension, dissipating the energy as heat. The design of the piston, valve systems, and fluid properties determines the damping characteristics of the shock absorber (Koni). Gas Damping incorporates gas-filled shock absorbers, also known as gas-charged or gas-pressurized shock absorbers, which contain high-pressure gases, such as nitrogen, along with hydraulic damping. The gas helps reduce the aeration or foaming of the hydraulic fluid, ensuring consistent damping performance (ZF). Gas damping provides quicker response and improved control over suspension movements, especially during rapid compression and rebound cycles. The damping characteristics of shock absorbers are typically defined by Rebound Damping and Compression Damping. Rebound damping controls the speed at which the suspension extends after compression. It influences the rate at which the suspension returns to its normal position. Proper rebound damping helps prevent excessive bouncing and maintains tire contact with the road surface, preventing sliding (TVSMotor). Compression damping regulates the speed at which the suspension compresses during upward wheel movements. It controls the rate of weight transfer, reducing body roll and maintaining stability during cornering or braking. By providing controlled damping forces, shock absorbers ensure that the wheels maintain optimal contact with the road surface, allowing the tires to effectively grip and transmit forces (BikeRadar). This improves traction, stability, and handling, contributing to safer and more predictable vehicle behavior (RideApart). Shock absorbers are available in various designs and technologies to suit different suspension configurations, vehicle types, and performance requirements. Advanced shock absorber systems, such as adaptive or electronically controlled dampers, can continuously adjust the damping characteristics based on real-time road conditions, vehicle dynamics, and driver inputs.

Control Arms (A-arms): Control arms control and constrain the motion of the suspension system. They provide a pivot point for the vertical movement of the wheels, allowing them to move up and down in response to road irregularities while keeping the body of the vehicle relatively stable (MoogParts). Control arms are typically found in independent suspension systems, where each wheel moves independently. Control arms consist of a sturdy metal structure, often shaped like an "A" or a wishbone, with one end connected to the chassis and the other end attached to the wheel hub or suspension upright. The control arm design may vary depending on the suspension configuration and vehicle requirements (BlueStarInspections). They provide Wheel Location and Support where the control arms serve as a structural link between the vehicle's chassis and the wheels. They help position and support the wheels, maintaining their proper alignment with the vehicle body and the road surface. This alignment is crucial for stable handling, predictable steering response, and optimal tire wear. Control arms also work in Vertical Wheel Movement where control arms allow vertical wheel movement in response to road irregularities, such as bumps or dips (Lesueur). This movement ensures that the tires maintain good contact with the road surface, improving traction, and enhancing ride comfort. The control arms work in conjunction with the springs and dampers to absorb shocks and vibrations, minimizing their transfer to the vehicle's body. Control arms play a significant role in controlling the suspension geometry, including the camber, caster, and toe settings. These geometric parameters affect the tire contact patch, tire wear, and overall handling characteristics of the vehicle (ScienceDirect). Proper control arm design and alignment help optimize these parameters for better stability, cornering performance, and tire longevity. In load distribution, control arms assist in distributing the weight and forces exerted on the suspension system. They help transfer vertical loads from the wheels to the vehicle's chassis, ensuring balanced weight distribution between the front and rear wheels (UQAC). This balance contributes to improved handling, stability, and braking performance. To withstand the forces and stresses encountered during operation, control arms are typically made of durable materials such as forged or cast steel, aluminum alloy, or composite materials (JDPower). They are engineered to provide adequate strength, stiffness, and flexibility, taking into consideration factors such as vehicle weight, expected loads, and performance requirements.

Anti-roll Bars (Sway Bars): In a suspension system, anti-roll bars, also known as sway bars or stabilizer bars, play a significant role in controlling body roll during cornering and enhancing the overall stability and handling of a vehicle. They are crucial components that connect the left and right sides of the suspension system and work to resist the roll or tilting motion of the vehicle's body. The primary function of an anti-roll bar is to reduce body roll during cornering or when subjected to lateral forces (Torque). When a vehicle turns, the weight shifts towards the outer wheels, causing the body to roll or lean away from the direction of the turn. These rolls can lead to decreased tire contact with the road surface, resulting in compromised handling, reduced traction, and potential loss of control. An anti-roll bar consists of a metal bar that is connected to the suspension on both sides of the vehicle (SuspensionSecrets). It is usually positioned horizontally and mounted near the front and/or rear axle. The anti-roll bar is attached to the suspension components, such as control arms, using links or bushings that allow rotational movement. The anti-roll bar works by transferring the roll forces from one side of the suspension to the other. When the vehicle experiences body roll, the anti-roll bar twists or resists the twisting motion. This twisting action creates a force that acts against the roll, helping to keep the vehicle level and reducing the amount of body lean during cornering (Torque). The effectiveness of an anti-roll bar depends on its design and characteristics. The diameter or thickness of the anti-roll bar affects its stiffness (SoDialed). A larger diameter bar offers more resistance to twisting and provides a greater anti-roll effect, reducing body roll more effectively (AxleAddict). The length and shape of the anti-roll bar determine its leverage and torsional characteristics. These factors influence the amount of force applied to the suspension and the overall roll stiffness. The attachment points of the anti-roll bar to the suspension are strategically positioned to optimize its effectiveness (SuspensionSecrets). The anti-roll bar links or bushings allow the bar to twist and transmit forces between the suspension components. By reducing body roll, anti-roll bars help maintain better tire contact with the road surface, improving traction and cornering capabilities (Grassrootsmotorsports). They contribute to more predictable and stable vehicle behavior during aggressive maneuvers, minimizing body roll-induced weight transfer, and enhancing overall stability and handling performance. It's important to note that while anti-roll bars provide benefits in controlling body roll, they also introduce a degree of stiffness to the suspension system. This stiffness can affect ride comfort, especially on uneven road surfaces, as the anti-roll bar limits the independent movement of the wheels. Therefore, the design and tuning of anti-roll bars involve finding the right balance between improved stability and maintaining acceptable ride quality.

Bushings and Bearings: Bushings and bearings serve critical functions in supporting and allowing the controlled movement of various components in suspension systems. While they have similar purposes, they differ in terms of design and the type of motion they facilitate. Bushings are cylindrical or sleeve-like components made of rubber, polyurethane, or other materials with high elasticity and resilience. They are typically used in applications where there is a need to dampen vibrations, absorb shocks, and provide a degree of flexibility while maintaining stability (AEComponents). In a suspension system, bushings are commonly found in the connections between the suspension arms or control arms and the chassis or subframe. Bushings provide a flexible connection by acting as a flexible interface between rigid components, allowing relative movement while maintaining structural integrity

(MetrixPremiumChassisParts). They enable controlled movement and allow the suspension components to articulate and respond to road irregularities. It also absorbs vibrations and noise as the elastic properties of bushings help dampen vibrations and isolate the suspension system from the chassis. They reduce the transfer of vibrations and noise generated by the wheels and road surface, resulting in a smoother and more comfortable ride (GMTRubber). Bushings help maintain proper alignment between suspension components, ensuring that they remain in their intended positions. This alignment is crucial for optimal handling, stability, and tire wear. Bushings reduce friction and wear between the moving parts of the suspension system. They provide a low-friction interface, allowing for smooth and controlled movement of the suspension components. Bearings, on the other hand, are mechanical devices that facilitate rotational or linear motion between two parts. They consist of an inner and outer race with rolling elements, such as balls or rollers, that reduce friction and allow smooth movement (SchaefflerGroup). In a suspension system, bearings are commonly found in the wheel hubs and various pivot points. They enable smooth rotation or movement by reducing friction between rotating or moving components, allowing them to move freely with minimal resistance. They facilitate smooth rotation of the wheels around the hub or allow controlled pivoting of suspension arms. They also distribute the forces and loads encountered during suspension movement, preventing excessive wear and stress concentration on specific components. They help ensure uniform load distribution, enhancing durability and longevity. Depending on their design, bearings can support both axial (parallel to the axis of rotation) and radial (perpendicular to the axis of rotation) loads (SaintGobain). This capability is crucial for handling the complex forces experienced in a suspension system. Bearings provide a high degree of precision and accuracy in rotational or linear movements, contributing to improved handling, responsiveness, and overall suspension performance. Common types of bearings used in suspension systems include ball bearings, roller bearings, and tapered roller bearings (EngineeringHulk). These bearings are typically made of steel or other materials with excellent load-bearing capacity and durability.

Steering Components: Some suspension systems, particularly those with independent front suspensions, integrate steering components. Steering components work in tandem with suspension components to facilitate the controlled steering of the vehicle. These components play a crucial role in transmitting driver input to the wheels, allowing the vehicle to change direction, maintain stability, and navigate corners effectively. The steering wheel is the primary interface between the driver and the steering system (MoogParts). It allows the driver to exert control over the direction of the vehicle. Rotating the steering wheel initiates the steering process, transmitting input to the rest of the steering components. The steering column is a shaft that connects the steering wheel to the steering gearbox or rack. It transfers the rotational movement from the steering wheel to the steering mechanism, allowing the driver's input to be transmitted to the wheels. The steering gearbox (in older systems) or rack and pinion (in modern systems) are responsible for converting the rotational motion from the steering column into lateral movement. It translates the steering wheel input into the left or right movement of the tie rods (LibGuides). Tie rods are crucial steering components that connect the steering gearbox or rack to the steering knuckles or steering arms. They transmit the lateral movement generated by the steering mechanism to the wheels. Tie rods play a vital role in maintaining accurate wheel alignment and proper steering geometry. Steering knuckles or steering arms are structural components that connect the tie rods to the wheel hubs. They provide attachment points for the suspension components and enable the wheels to pivot for steering (DelphiAutoparts). Ball joints are pivotal connections that allow smooth movement and rotation between the steering knuckles or steering arms and the suspension components. They provide flexibility and freedom of movement for the suspension while ensuring proper steering alignment (MoogParts). In certain steering systems, such as the recirculating ball or parallelogram steering systems used in older cars or large vehicles (LinkedIn), the pitman arm and idler arm are employed. The pitman's arm connects the steering gearbox to the steering linkage, while the idler arm supports and stabilizes the opposite side of the steering linkage (Ditas). Collectively, these steering components work together to convert the driver's input into precise wheel movements, enabling the vehicle to change direction. As the driver turns the steering wheel, the rotational force is transmitted through the steering column, gearbox or rack and pinion, tie rods, and steering knuckles. The tie rods move the wheels in a synchronized manner, allowing the vehicle to steer smoothly. Proper steering geometry, alignment, and the condition of the steering components are crucial for safe and accurate steering response. Any wear, misalignment, or damage to the steering components can compromise the vehicle's handling, stability, and overall safety. Regular maintenance and inspection of the steering system are essential to ensure optimal performance and driver control.

The functioning of the suspension system involves a combination of these components working together. When a vehicle encounters irregularities on a road surface, springs compress or extend, absorbing the energy of the impact. The dampers control the springs' rate of moving, dissipating the absorbed energy. The control arms allow vertical wheel movement, adapting to road imperfections, while the anti-roll bars reduce body roll during cornering. The suspension system's design and configuration depend on various factors, including the vehicle's weight distribution, performance requirements, and intended use. Engineers carefully balance factors such as ride comfort, handling, and stability to optimize the suspension system's performance.

Suspensions in larger vehicles:

In large trucks, coil spring suspension systems are used due to the reasons mentioned above. However, the weight of trucks is significantly larger than passenger cars thus these suspension systems are only used in the front of the truck (UTI). Coil springs typically last 60,000 to 70,000 miles, sometimes reaching 100,000 miles in some cases (CuratedTaste). This is unlikely in trucks, however, as they are much heavier (6,000kg) the coil springs wear out a lot quicker (ArnoldItkin). The increased weight also increases the frequency of the vibrations which causes the coil to hit the bump stops more often and with a greater force (Pedders). This is because while the suspension on larger vehicles is stiffer, the weight overload or misbalance due to goods can result in the aforementioned issues.

We can observe the wearing out of a spring suspension system using a few other factors: uneven tired wear, rocking and even movement of the truck, lowered vehicle chassis, and leakage of oil around the shock absorbers (UTI). Transportation trucks are used mainly in the USA, China, and Canada which are all massive countries (Syntech). In China, 34.79% of the population (491 million people) live in rural areas (TradingEconomics), and in Canada, 84% of the population lives in suburban areas (NewGeography) with less-developed roads and rocky terrains. The USA has a population density of only 35.58 people per km^2 (MarcoTrends), showing how large distances are to be traveled to deliver goods.

According to research from StartRescue, these rocky terrains and small rocks damage the suspension systems. This is because when a tire is rotating, its grip and friction can cause some rocks to stick to it and rotate with it. This is more common in larger trucks where the tires are larger as they are usually plus 1 tires (Postletire). As seen in the picture below, the suspension system is located above the tires which makes it prone to damage. When these small rocks come up to the suspension system with the tire, a lot of times these rocks get stuck in the suspension system and bang against the coil, corroding it. This shortens the life of the coil by weakening it, thus hindering the performance of the suspension system over time. The suspension system is now less enduring and will need to be replaced sooner due to the damage caused by the rocky, rough terrains. The dust in these terrains caused by the tires bringing up dust from the surface can erode seals in the suspension system. Shock absorbers are usually placed in such seals to minimize friction (SKF) which when eroded causes increased friction, reducing the effectiveness of the suspension system. It can also be abrasive between moving parts such as in the coil which can further weaken the coil and reduce its life (OCC).

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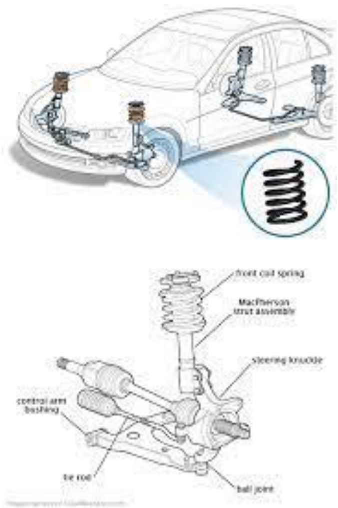
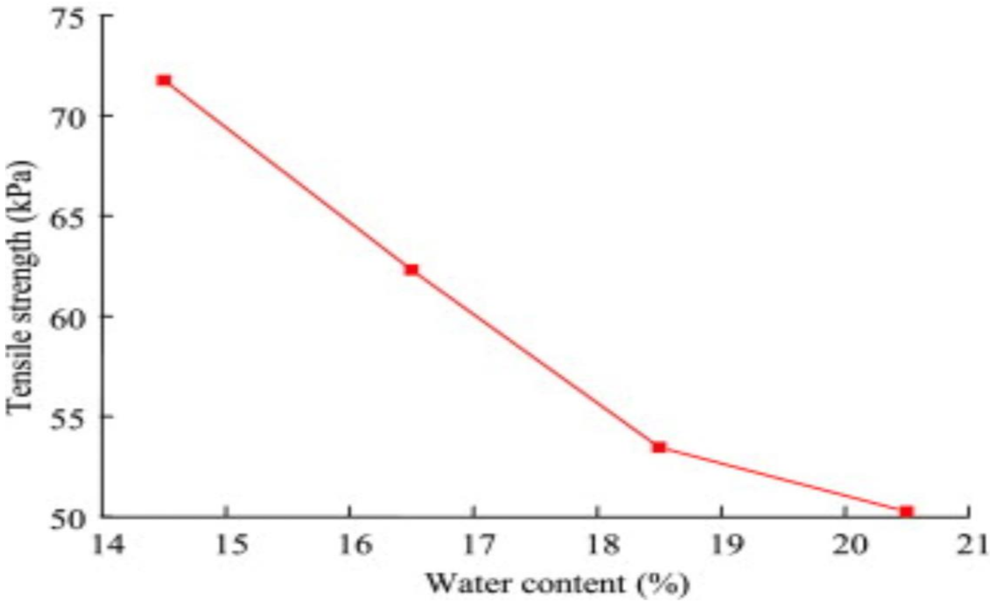


(RepairPal)

The paths in such rural areas also tend to have worse drainage thus causing flooding or residues of rainfall. 40% of Americans live in counties near the coast (NationalOceanService) where the heaviest rainfall is experienced (CoastalDreamLife). Regardless of coastal areas, other humid areas that experience a lot of rainfall also face the following issues. As mentioned before, these coils are made of hardened steel, an alloy of iron and carbon, they will rust. Rust is a common phenomenon in materials containing Iron as the Iron (Fe) molecules react with the Oxygen (O_2) molecules to create Iron Oxide which is known as rust (ZRCWorldWide). Rust weakens the metal. It hinders the structural integrity of the coil and limits the stability it provides to the car. This makes it a safety hazard as the steering responsiveness is then compromised which may cause unwanted issues while driving (InnovationDiscoveries). This is because of the wheel misalignment which can then cause the wearing of other parts of the car such as excess load on tires and other mechanical systems (GrimmerMotors). The weakening of the coil due to rust can cause excessive vibrations and increased noise as well which makes the ride more uncomfortable and makes goods more likely to fall and break.

The graph below depicts the effect of water content (humidity percentage) on the tensile strength of steel which is the maximum amount of stress steel can bear before breaking.



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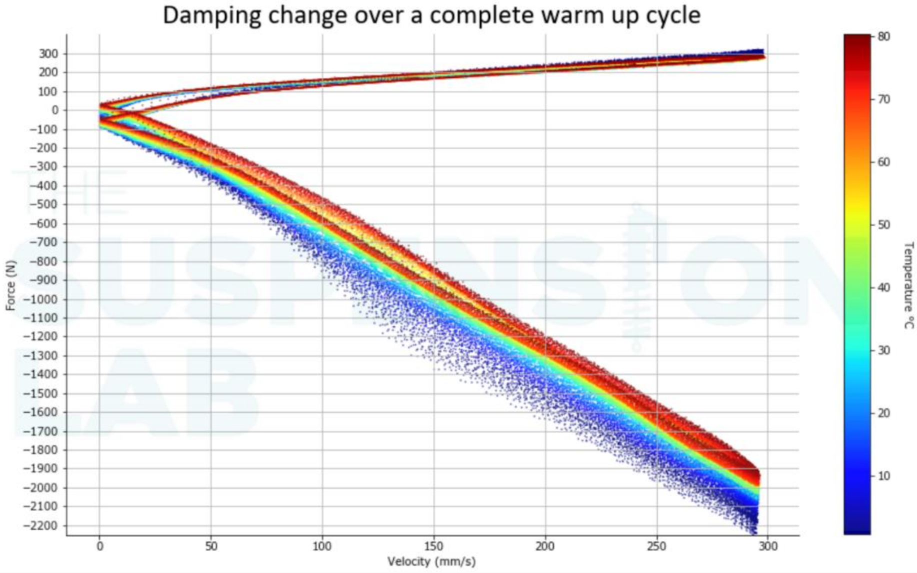
(Research Gate)

Another issue affecting the coils or suspension systems as a whole is temperature.



(The Suspension Lab)

As seen in the graph above, lower temperatures require greater forces to reduce the velocity of the oscillations and higher temperatures are more efficient. This is because of the oil. Under colder temperatures, the oil in the suspension system is more viscous due to thermodynamic changes which make the flow of the oil slower (Petroleum Service Company). This is because when a liquid is placed in a colder environment, the kinetic energy of the molecules reduces which causes the molecules to vibrate less. This makes the molecules more rigid and, thus, harder to move, hindering the liquid's flow. When the flow is less, the lubrication in the suspension system reduces as well. When there is a lack of lubrication in the suspension systems, the contact between the naked metal in the coil increases, and as metals have a higher dynamic friction coefficient than liquids, there is a greater amount of corrosion (Nergersn Auto Express). Lower temperatures also cause coils to become harder and brittle making them more susceptible to damage from smaller rocks and rough terrains (Am offroad). This is because the crystal lattice does not move which then causes long cracks to form between them when they are moved or bent (UIUC).

Alternatives:

The problems mentioned above can be fixed using other suspension systems. Leaf spring suspension systems are viable choices for all the truck's suspension systems are they are already implemented.

The simulation below uses finite element method-based analysis from OnScale

Model with a force of 15000N and restraint in all 3 axes:

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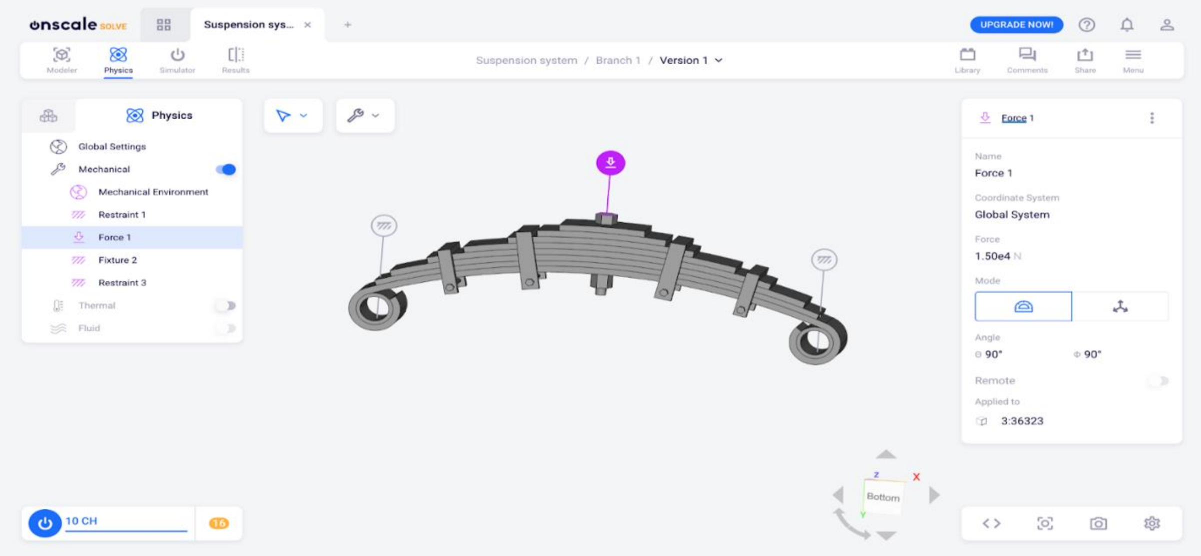
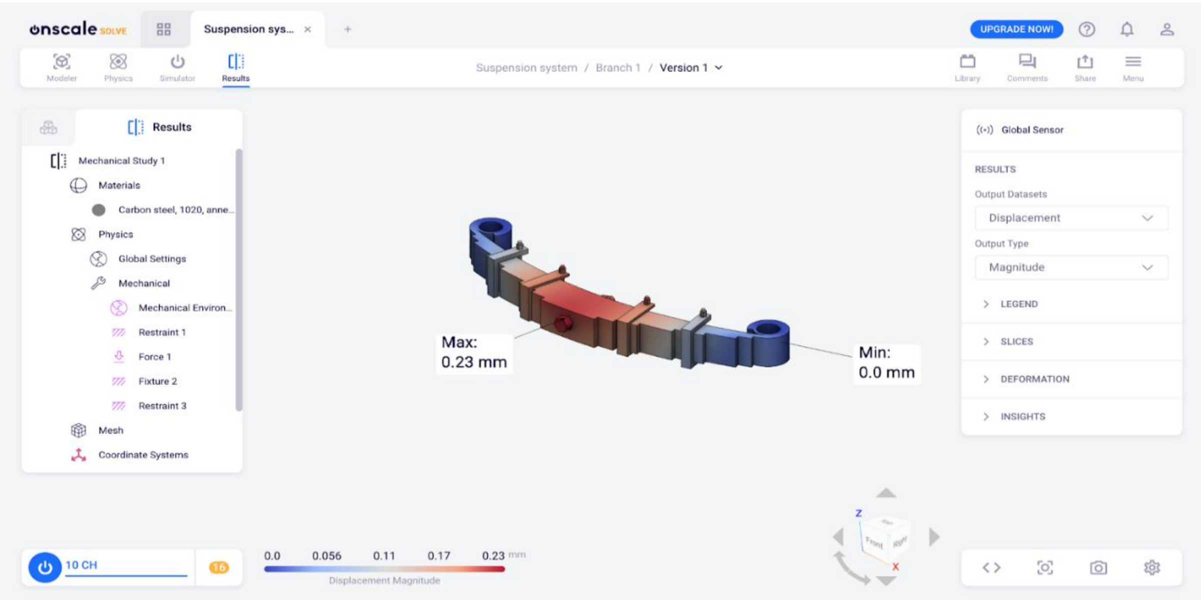


Simulation Result:



As seen by the results, the largest stress is placed towards the middle of the leaf-spring system. This makes it necessary for support towards the center in order to prevent breaking and irregularities. The suspension system must be coupled with clips and straps that are bolted onto the frame of the vehicle along with U-bolts. Leaf spring suspension systems are not as susceptible to being deformed due to these additions. To add additional support to the middle of the spring, a helper spring can be utilized. Doing so, will relieve the pressure from the middle of the spring and disperse it over a greater surface area.

pressure = Force / Area => P = F/A

Using this formula, increasing the area can help reduce the pressure on the stress points as the ratio of force to area decreases.

Additionally, using the formula mentioned below, we can estimate the bend of the leaf spring system based on the force applied and its length. This can help in optimizing the size and material of the suspension system by ensuring that the spring does not bend beyond its maximum shape retaining point.

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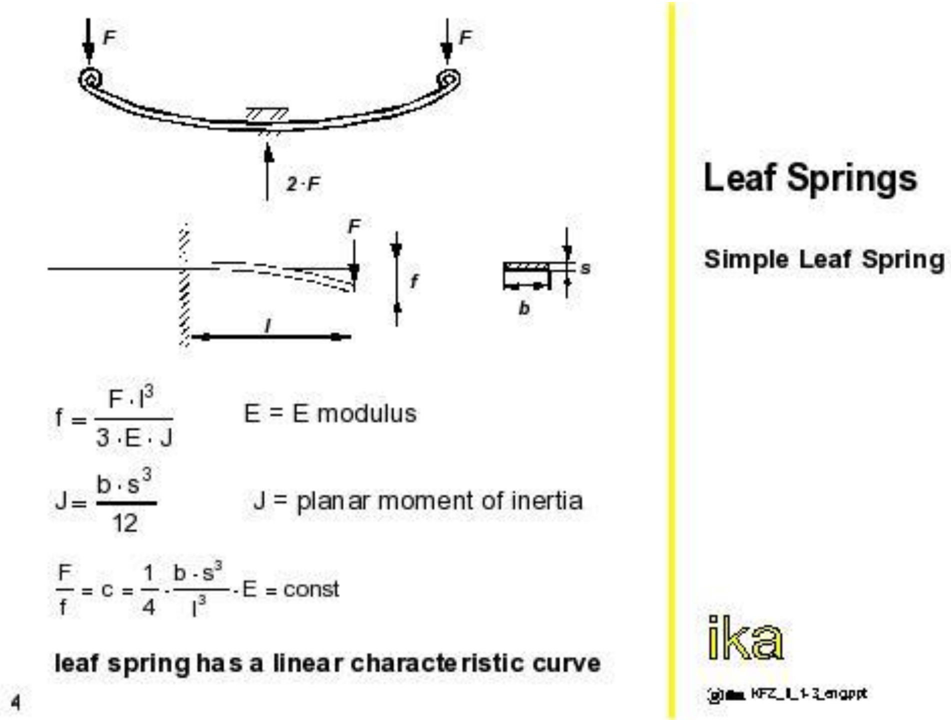

(Euro Motor)

The coil spring suspension system uses high and medium carbon steel, chromium-vanadium steel, chromium silicon steel, and stainless steel. In comparison, leaf spring suspension systems use steels that include 0.5% of carbon along with amounts of manganese, chromium, and silicon. This is called low-alloy steel. We can compare these properties in the table to determine the functionality and strength of these materials.

Material Analysis:

Coil Spring Suspension System				
Material	**Stress Point (PSI)**	**Composition**	**Tensile Strength (MPa)**	**Corrosion**
Carbon Steel	60,000-80,000	Iron- 97% Carbon- 0.12 – 2.00%	400-600	Likely
Chromium-vanadium Steel	113,000	Carbon- 0.50% Manganese- 0.70-0.90% Silicon- 0.30% Chromium- 0.80-1.10%	300	Unlikely

		Vanadium- 0.18% Iron- 97%		
Stainless Steel	18,750	Chromium- 10.5% Carbon- 1.2% Iron- 88%	540-625	Unlikely
Leaf Spring Suspension System				
Material	**Stress Point**	**Composition**	**Tensile Strength**	**Corrosion**
0.5% Carbon Steel	90,000	Carbon- 0.5% Iron- 98%	540	Likely
Stainless Steel	18,750	Chromium- 10.5% Carbon- 1.2% Iron- 88%	540-625	Unlikely

Conclusion:

Suspension systems are important in several aspects of transportation and vehicles are the largest users of suspension systems. While the designs of suspension systems are appropriate and each has a working mechanism, the use of coil spring suspension systems may not be the most effective means of enhancing the consumer experience in vehicles. They have some limitations that can cause problems in the longevity of the vehicle. These include humidity which causes corrosion, small rocks, and higher temperatures which affect the structure and the lubrication of the system. The system will require repairs sooner than other systems and will need constant re-lubrication for the appropriate functioning of the coil spring suspension system. Leaf spring suspension systems work in a manner that can reduce costs on maintenance and further enhance the vehicle's stability and longevity. Leaf spring suspension systems still require further analysis specifically on material analysis to ensure materials are rigid but not too rigid. Their implementation in the world has seen great benefits with trucks, in general, being able to drive more miles, despite being significantly heavier than regular cars, due to these suspension systems. The stress and material analysis must be done in order to implement such a mechanism in regular cars and to widen the application of this type of suspension system.

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