Dampers: the unsprung hero of your car?

We all know that dampers have an important role to play, particularly on a lightweight, high performance car like a Seven – just witness the number of posts on BlatChat over the years which concern the relative merits of one make over another. Types (and prices) vary widely, from the Bilsteins supplied as standard on most new Caterhams to one, two and even three-way adjustable versions often favoured by the race teams (at least, where regulations allow). But how many people really understand what a damper does? What are the genuine merits of different types? How easy is it to change your dampers? What maintenance do they need?

In the first of a two part article, **Simon Rogers** of suspension specialists Meteor Motorsport helps to guide us through the maze.

So, back to basics – what exactly does a damper do?

At its most fundamental, a damper is essentially an oil pump, which is mounted between a car's body and its wheels. The upper mount of the damper connects to the chassis (everything from this point up is generally referred to as the "sprung weight"), while the lower damper mount connects to the wishbone or axle near the wheel (this is known as the "unsprung weight").

We all know that cars are fitted with springs which have the job of absorbing the inevitable bumps in a road or track. However, if there wasn't also a damper fitted, when the car wheel encounterd that bump, causing the spring to compress, the spring would then quickly extend back at an uncontrolled rate to release the energy which it had absorbed. It would then continue to bounce at its natural frequency until all of the energy put into it had been used up. A suspension built on springs alone would therefore make for an extremely bouncy ride and, depending on the terrain, for an uncontrollable car. This is where the damper comes in – it controls unwanted spring motion by slowing down and reducing the magnitude of the spring's motion by turning the kinetic energy of movement into heat energy which can be dissipated through the hydraulic fluid which it contains.

With the combination of spring and damper in place, now when a car encounters a bump which causes the spring to coil and uncoil, the energy of the spring is transferred to the damper through the upper mount, down through a piston rod and the piston. Here, carefully designed channels allow the fluid to leak past in a controlled way as the piston moves up and down a pressure tube. Because the orifices are relatively tiny, only a small amount of fluid, under great pressure, can pass through. This slows down the piston, which in turn slows down the spring.

So, what's inside a damper?

To understand how a damper works, we will take a look inside to see its structure and function. However, key to understanding the mechanics going on is recognising that dampers work in two independent cycles -- the compression cycle and the rebound cycle. The compression cycle occurs as the piston moves downward, compressing the hydraulic fluid in the chamber below the piston. The rebound cycle occurs as the piston moves back towards the top of the pressure tube, which compresses the fluid in the chamber above the piston. A typical car will have more resistance during its rebound cycle than its compression cycle. With that in mind, the compression cycle can be thought of as controlling the motion of the vehicle's unsprung weight, while the rebound controls the heavier, sprung weight.

So, what control does a damper have on a car's motion?

All modern dampers are designed to be speed-sensitive – ie the faster the suspension moves, the more resistance the shock absorber provides. This enables dampers to adjust to road conditions and to control all of the unwanted motions that can occur in a moving vehicle, including bounce, sway, brake dive and acceleration squat.

So, let's take a look inside a damper (right) The arrows show the movement of the piston and of the corresponding oil flow inside the damper when it is under compression. (with thanks to Quantum Racing Shocks for the use of the image).

The inside of the shock absorber can be divided into three chambers:

- The compression chamber (A), the rebound chamber (B) and the gas chamber (C). The compression and rebound chambers contain oil, and are either side of the piston. The gas chamber contains nitrogen, which is kept separate from the oil behind a separate floating piston.
- At rest, the pressure inside all of the chambers is equal. All the time the shock absorber is fully extended, this will be consistent with the recommended gas pressure.
- When the shock absorber is caused to move, the piston moves through the oil. Oil flows through the jet (D) and around the needle (E). It enters the rebound chamber via cross-drillings in the shaft. The restriction of the oil flow will cause a pressure differential either side of the piston. In compression, pressure inside the rebound chamber will decrease. In extension, pressure inside the rebound chamber will increase. At all times the pressure inside the compression chamber will remain consistent with that inside the gas chamber (C)

So, what makes one damper different from another?

Although the fundamental operation of every damper is pretty much the same, different manufacturers use different design details in an effort to optimise the behaviour of the damper to provide the best possible performance. Considerations such as the materials used, the design of key parts, and the diameter of the piston will all have an effect on the damper's

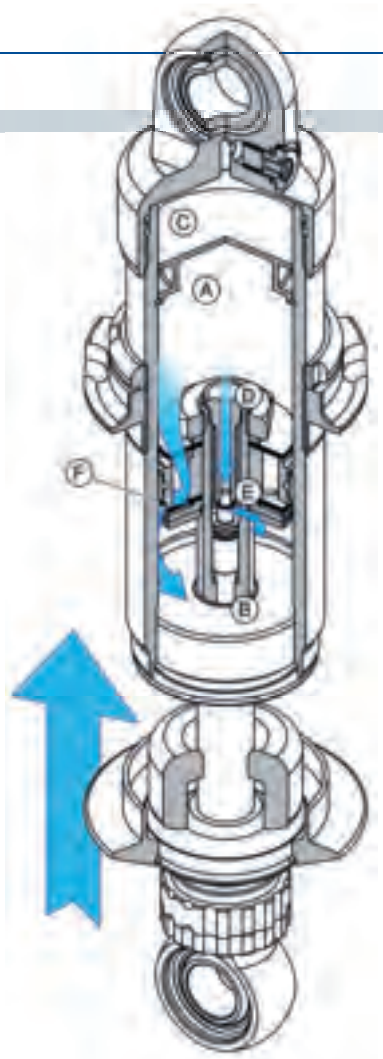
behaviour. Equally, a damper manufacturer has a great degree of flexibility to fine-tune the damping behaviour of the unit through choices made in the orifices through which the oil travels as the piston moves up and down. Typically, the piston will have a jet through which the oil can pass when the damper shaft is moving at low speed. However, once the damper starts to move at a higher speed, the jet can no longer cope with the demand for the fluid to move through, so instead, it will be forced through a stack of shims on the end of the piston (F). It is this transition from oil going through the jet to oil moving through the shims which allows a damper to be "velocity sensitive" and through which it can be tuned for its specific application.

A suspension engineer will typically take many days of testing to select the optimum combination of shims which he believes will best suit a particular car for a particular application. A top race team may be able to do this in between events, but of course for road cars like most Sevens, we have to trust that this work has been successfully carried out by the damper designer and that what we are buying is suitable for purpose. There are many dampers on the market which will fit a Seven, and many look very similar from the outside, but before deciding to spend any money on a damper upgrade, it is vital to ensure that what you are buying has been optimised for the Seven application. In addition, dampers and springs are designed to work together, and the damper configuration and spring rates need to be carefully matched. This is not to say that significant improvements in the handling for you Seven cannot be achieved – they can, but it pays to learn from the experience of others and to ensure that whoever you choose to go to for your parts has the experience to advise you appropriately.

What adjustment is available to the user?

Although the damper manufacturer / designer will have had the greatest amount of input into the behaviour of the unit, another significant consideration in the selection of a particular model is likely to be the degree of adjustability which is available to the end user. The simplest dampers are "non-adjustable" – an example would be the Bilsteins fitted as new to most Caterhams. As the name suggests, these offer no scope for adjustment by the owner, but as long as these have been specified by the manufacturer to match what they believe to be the optimum setup for the car, under most conditions such non-adjustable dampers will be perfectly sufficient for many users.

However, "one way adjustable" dampers are a popular upgrade for many owners. On these types, turning a knob moves a restrictor inside the damper which either increases or decreases the restriction around the jet between the chambers. Going back to our earlier explanation of how a damper works, this effectively changes



the point at which the oil is no longer able to pass through the jet alone, and instead starts to be forced through the shims. Turning the adjustment knob on most "one way adjustable" dampers has the effect of modifying the damper's behaviour in both compression and rebound, although designs where only one of these two aspects is affected are available.

Two way adjustable dampers are also available, although at this point, we are getting more into the realm of professional racers who have the opportunity for detailed testing and experimentation to optimise a car's setup for a particular set of conditions. Two way dampers allow the race engineer to adjust the behaviour of the damper in compression and in rebound separately.

Three way dampers, (definitely the preserve of the top race teams) allow separate adjustments to be made to slow and high rate compression as well as to rebound.

So, why might I choose to change my dampers?

The starting point will vary depending on what your car is currently fitted with. First of all, it is a fact often overlooked that dampers are not a "fit and forget" item. Dampers have a hard life, even on a car as light as a Seven. Different manufacturers will have different recommended service schedules for their dampers, but most typically recommend that they should be looked at every two to three years. Other than complete mechanical failure (which is thankfully rare), most dampers will wear slowly, such that an owner is unlikely to notice the steady degradation in handing which is taking place. The good news is that most good quality dampers are designed to be brought back to their full performance via a service rather than needing to be replaced, although some owners may take this as an opportunity to upgrade rather than repair.

Many owners change their dampers because they want additional adjustment opportunities to fine-tune their car's handling to suit their own driving style. As well as a fixed damping setting, many non-adjustable dampers do not have the facility to alter the car's ride height either. This is particularly important for owners who want to set their car's "corner weights" to optimise handling, but it is also often important to drivers who intend to fit wheels or tyres of different ride heights. Any owner looking to resolve a handling problem (such as persistent under or oversteer) is likely to start by looking at the car's geometry setup as well as the damper/spring combination fitted.

And yes, aesthetics often play a part too. The front dampers on a Seven are extremely visible, and it is generally accepted that most buyers, when faced with a choice between two dampers of equal performance will go for the nicely anodised version over the dull metal one…

Two key aspects of a car's geometry are its ride height and its rake (the balance of the car from front to rear). So, does the damper set the ride height?

This is a common misconception. It is actually the length of the spring which controls the ride height (assuming a given spring rate). However, dampers with adjustable spring seats can be used to change a car's ride height by moving the spring. Some people assume that moving a spring seat will also change the spring rate, but this is incorrect – the spring rate is set by its design, and, other than specialised progressive springs, will not change through the spring being more or less compressed. Spring rates are typically measured in lbs/inch - thus a 500 lbs spring will compress by 1/2 inch if a load of 250lbs is placed on it, by 1 inch with a load of 500lbs and so on.

Hopefully the above will help clarify some of the common questions about the role that a damper plays, and some of the considerations which you may want to take into account when selecting a set for your car. Next month, we take a look at how a damper is serviced, and consider some of the things which can go wrong with them. We also look at how a damper is tested to check its performance against its expected characteristics, as well as the practicalities of how to remove and refit the dampers on your Seven. ***LF***

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