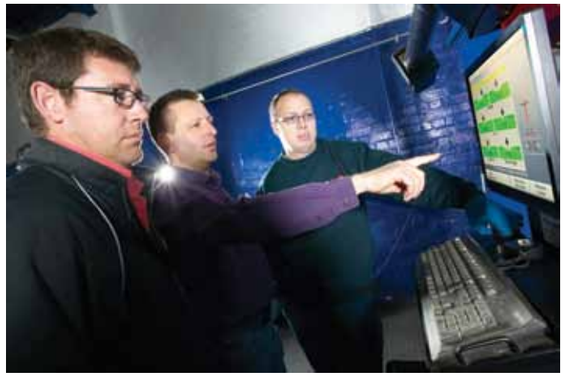
THE ‘INSIDER’

Our unique access to Peter Cambridge, the former Prodrive chassis development engineer and now independent tuning consultant, has led us to the ‘Holy Grail’ of suspension management and his informative findings will help you to make better considered decisions for your Subaru project.

GETTING IT RIGHT AROUND THE BEND



Alignment is not one of the most enthralling aspects of modifying cars. Usually it is only a consideration, when a new set of tyres is purchased and the fitting centre offers to check and adjust your vehicle’s alignment (and it needs to be said that, even working with manufacturer figures, they do not always get it right).

Having spent years tuning the suspension systems of cars, I have learned the importance of correct alignment to get the car to work for the driver, so that he or she feels in-charge and confident enough to exploit all of the available grip. ‘Alignment’ is really the wrong terminology, as it implies that everything should be pointing in the same direction. However, ‘static geometry setting’ is a more accurate description, as the engineer is setting the axis, about which the wheel rotates in three dimensions. It should be remembered that it does not represent exactly what the wheels are doing, when the vehicle is moving and being loaded from different directions, but it does establish the nominal values through which it moves.

To demonstrate this, I set-up an event at Protyre (www.protyre.co.uk) in Warwick, a company that I use, when setting the static geometry of customers’ cars. My aim was to show the significant effects that static geometry settings have on the manner in which a car steers and handles, so that Impreza owners can garner some knowledge to make their cars better dynamically, or significantly closer to their liking, in exchange for a relatively small financial layout, when compared with other, more involved suspension modifications. Naturally, I needed a willing victim, preferably with an Impreza and, using my contacts at Cross Roads Subaru in Shipston-on-Stour, Warwickshire, I contacted an owner, who was prepared to entertain the project.

FIRST IMPRESSIONS

There was a tremendous sense of both satisfaction and déjà vu, when I was confronted by the metallic grey, 1998 STi v5 Type R, as it arrived at Protyre, driven by its owner, Spencer Grey. The two-door outline reminded me of the P1 model, back in 1999, with which I was closely associated. In fact, this car was originally white, like my P1 development car, but it had been re-sprayed in the classic metallic grey of the RB5. It was a special car, with the driver-controlled centre differential (DCCD) missing from the P1 due to its incompatibility with ABS, at the time. It was a near-standard example of a Japanese Domestic Market (JDM) car, possessing only a few pertinent modifications. The front spoiler/valance was a Tommy Kaira item and the exhaust system was a rare Kakimoto Racing Regu 92db-z. It translated into a sonorous soundtrack that was just the legal side of loud.

The owner has a plan for this car that has been thoughtfully created. It is going to become a track tour example, heading to both UK and European circuits, including Spa and The ’Ring. As well as being fast, it needs to be reliable. The target for the engine is 380bhp, with extensive intake and turbocharger changes, accompanied by cooling and baffling modifications to aid its longevity. A Simtec ECU will control all the fuelling and ignition requirements, being programmed to allow a pair of maps, one for track use and the other to help retain the driver’s licence on the road. Fitted with a set of 18.0-inch diameter alloy wheels, clad in Toyo R888s, will ensure that it sticks to the tarmac and a larger all-round brake kit will slow the entertainment, when safety and restraint demands it.

As it transpired, Spencer was the perfect owner to experience the changes made to his Impreza for this feature. As well as being a car dealer and owner of a VW camper conversion and rental business, called Camperking, he also writes for the magazine ‘Adventure Bike Rider’. Familiar with assessing motorcycles and their related products, applying his critical mind to addressing the handing of his car was going to present a memorable challenge.

Naturally, it would also be a challenge for me, as I knew what to expect from the changes but I needed to understand Spencer’s feelings and how he might translate them into words. In all cases, I have endeavoured to use his precise turns of phrase, following each of the following alterations. I hope you are able to relate to them.

I have also provided a description of what I expected the changes to achieve from my twelve years of experiences with the Impreza. Some of Spencer’s comments were as I envisaged but he also observed differences in his car’s body motions that, upon initial explanation, were at odds with the aim of the desired setting. Yet, on contemplation, they were the consequence of the changes made. It was an education for the both of us, let me tell you.

TECHNICAL SUPPORT

The manager of Warwick Protyre, Ray Port, had nominated his top technician, Darren Sturdy, for the role of setting-up the car and the subsequent resetting processes throughout the day. He definitely had drawn the short straw.

Protyre has a state-of-the-art camera-based alignment system. Manufactured by John Bean and Hunter in the USA, it makes setting geometry a quick and accurate process. No jacking is required. The car is driven simply onto the ramp, targets covered with a specific pattern of spots are fitted to each wheel and, with little more than a quick roll backwards and forwards to allow for any run-out in the wheels, ‘Hey presto!’, the geometry figures are measured and displayed on-screen.

Firstly, we measured the car as it had arrived that morning, in order to comprehend Spencer’s handling experiences. Importantly, the car’s fuel tank was full. Most static geometry figures are quoted by car manufacturers in this ‘kerb’ load condition. Some go as far as to specify either a certain mass to be added to the car, to represent

> a driver and passenger, or that the ride height should be measured and the figures entered into the computer. The reason for this is to account for 'bump steer' and 'camber change' characteristics of the front and rear axles, which cause the toe and camber settings to alter with ride height.

Many text books on chassis tuning state that any bump steer is bad. In fact, the 'correct' level of bump steer is crucial to making vehicles handle and steer effectively, while also providing the commensurate level of stability. Generally speaking, on the front axle, as the wheel travels up into 'bump', it toes out, while, at the rear, it toes in. The amount by which it steers is described in degrees per metre. Cars that are notably 'twitchy' can be calmed down, by increasing the gradient (more toe out with bump on the front), and cars that are a little 'boring' can be made more responsive, by reducing the gradient, or the amount of degree change per metre. If a car toes in into bump at the front, then it can feel very responsive but become unstable, which is neither helpful on the road nor when driven at higher speeds.

POSITIVE INFLUENCES

The effects of the bump steer are also influenced by other factors, known as compliance steer. Cornering, accelerating and braking forces load the bushes in the suspension and sub-frames in different directions and have other steer effects. It is a complex business that is analysed and then measured, sometimes to extremes, on new model programmes. However, it is the human touch, in most car companies, that determines finally what they all should be for a particular car or its derivative. When these characteristics are set appropriately, a car can be easy to drive, adjustable when the driver demands it, yet remaining stable, when the unforeseen event happens in the middle of a bend or deflection.

Spencer's car measured up like new. We were both amazed. The suspension was completely standard and there was no evidence of it ever having been adjusted. The rear toe was parallel, meaning the total toe was 0°00'. It was biased slightly toe out on the right

> and toe in on the left, which would give a slight proportion of steer of the car's rear towards the right. To keep in a straight line the driver would have to apply a little right hand lock. This is known as the thrust angle. I always set cars to have a thrust angle of less than +/- 0°02'. It is tighter than most manufacturers' specifications but worth attempting to achieve. The front toe was 0°04' total. There was an average of -1°20' of negative camber on the rear wheels and -0°45' on the fronts. All were well within Subaru's factory specifications.

We made one discrete change at a time, to ensure that the differences felt could be attributed directly to it. Combining too many changes in one go may sometimes yield the results required but confound an understanding of why it worked. We drove the same route each time from Warwick into the countryside with roundabouts and a variety of both low and high speed corners. We started at the rear by setting a little toe out, within the factory specification, of -0°04' per wheel.

Spencer Grey (SG): ***"Under power the tipping point (start of oversteer) felt clearer, it felt like it was going to 'let go'. The first time on a roundabout, it went sideways off the throttle. Second time, with more use of the throttle, it was looser but not uncontrollable. The centre of gravity felt higher. More oversteer is what I want. It was better than standard."***

Toe out at the rear is often used in front wheel drive circuit cars to counteract initial understeer and on rally cars to help initiate the turn on the loose by keeping the car unstable (it is what most rally drivers prefer). It gives an un-natural feel to the car in that the front and rear appear to be unconnected, as the rear seems to steer itself. It is a completely different feel to sliding the rear. As a driver, you find that you have to make constant small steering corrections.

Next, we made a large change on the rear. We went for a significant amount of toe-in. It was set to the P1 level of +0°15' per wheel.

SG: ***"The front felt tighter, more positive. The car felt much flatter. There was less roll and yaw. It felt as though there were more weight over the front. The initial turn-in was better. Half-way around the roundabout, it started to wash out. The car felt lower. It started to go (oversteer) without throttle."***

The big surprise for Spencer was that a large change at the rear was felt at the front with a more precise turn-in. The car pivoted around its back axle and felt both taut and responsive. The rear tyre was running at a small slip angle in a straight line and was ready immediately to provide cornering force, upon request, by inducing a small turn of the steering wheel.

FRONTAL ASPECT

Leaving the rear suspension in the last setting, we moved to the front, setting the toe-out to -0°04' per wheel.

SG: ***"There was just throttle oversteer (neither lift-off nor steady-throttle oversteer). Car felt 'wider' at the front. Had to request oversteer. All down to the throttle. Neutral feeling. More oversteer returned – good, but no unstable feeling. Turn-in was okay. Not lost any steering. More planted on all four wheels."***

Toe out on the front tends to slow down the initial turn motion of the car. It is especially noticeable at high speed and is a negative characteristic, if you are a driver that likes to feed a car into a corner. However, it can help to calm down a car that feels too responsive. From the passenger seat, I could see that a little more steering lock was being used by Spencer for the corners.

To make a dramatic change to the feeling of the car, we adjusted the toe-in on the front, setting it to +0°04' per wheel.

SG: ***"Balance felt like it dived onto its nose. Felt like it rolled more. I am amazed how small adjustments make such a huge difference and some of them that seem like large adjustments are fairly insignificant."***

These comments were really interesting for me, as they were not what I had expected. The small amount of toe-in tends to give a good initial steering response with no delay, or dead band, on-centre. What Spencer noticed was not an 'improvement' in steering response but an 'increase' in the rate of roll. The increase in roll rate was due to the car generating the cornering forces more speedily. If the car had tight dampers, then the change in body motion would not be noticeable, although the gain in steering responses would be more obvious. The driver's personal preferences play a huge part in this instance.

We set the rear to minimum negative camber, even though it is 'not' adjustable. As I mentioned in a previous article, by loosening the rear strut to knuckle bolts, it is possible to take up all the clearances and reduce the negative camber by a small amount. We now had an average of -1°10' which is about 10' less than before.

SG: ***"Didn't expect much difference to run to, as there was very little movement obvious at the bolts. Surprised by the complete change of handling character. Brought understeer back into check. Felt neutral. No oversteer but 'slingshotted' around the corner. Initial brief understeer then, with more throttle and seeking understeer, it ended up with a small oversteer."***

Reducing negative camber would give less cornering grip from the rear tyres and help to reduce the natural understeer balance in the Impreza. It is an improvement for free, which is a rare commodity.

As a final test, we set the front negative camber to the maximum possible, using the eccentric bolt attaching the strut to the knuckle. We also took up any clearances around the fixings, by leaning on the wheel as they were tightened. This gave us a negative camber of -1°20'.

SG: ***"Gripped very well. Wouldn't slide (understeer). Tightened it all up. Cornering 'G' was a lot higher. The car was not the limiting factor. Cornering limits were higher than I was comfortable with."***

The increase in negative camber gave the front tyres a lot more cornering grip that could be used to good effect by Spencer. The long-term trade-off is some increase in tyre wear, on the inner part of the tread, if the car were to cover a lot of motorway miles. -0°45' is a sensible maximum value for good tyre wear.

Finally, we set the car in the way it appeared Spencer would like it, taking into account his comments for each of the changes. Front toe -0°04 per wheel, camber -1°20', rear toe +0°15' per wheel and camber -1°20'.

SG: ***"Flatter. Not on a knife edge, it was confidence inspiring. You could find the limit and it didn't want to spit me off. It was tolerant. Needs more power!"***

The final comment said it all. After optimising the car, Spencer became much more confident in applying all of its power through bends that he simply pleaded for more.

Clearly, the effects of changing the static geometry can be quite dramatic and can turn a good car into a really special one. Having a car aligned correctly is money well spent and will provide an even more enjoyable driving experience.

Please contact PCA Dynamics, if you are interested in having your Impreza's static geometry set, or if you would like to go through a similar exercise to Spencer, in order to optimise it, to suit your driving style and suspension specification. Contact: www.pcadynamics.com