Virtual 4 Post Rig Notes

1 Summary

This page aims to provide some notes on the exploitation of the Virtual 4 Post Rig simulation on the Canopy Platform. We firstly give some briefing notes on how one goes about achieving good correlation between the testing rig and simulation, and the confounding factors that make this difficult and limit its value. Apologies are offered to any readers for whom this is going over familiar territory.

2 Ride Correlation and Performance

Tyres and aero generally have a reputation as the darkest of arts in F1. I, however, would add ride performance to this list, not least because it has such a strong dependence on both aero and tyres, and a variety of oddities of its own. Correlation in ride performance has a tendency to be illusory and fleeting; I speak on the back of several frustrating but ultimately educational years chasing ride performance. There are in general two types of correlation we are chasing:

1. Correlation between simulation and the 4 post rig.
2. Correlation between simulation and the track. There is a 3rd area of correlation, about which we can do little, which is correlation between the 4 post rig and the track. This tends not to be particularly good, which limits the value of chasing simulation and 4 post rig correlation. The major confounding factors are discussed in the following subsections.

2.1 Tyres

Many virtual 4 post rigs use testing tyres, usually referred to as ‘rig tyres’ or ‘balloon tyres’, which are provided by the manufacturer with the aim of replicating the behaviour of a hot, rolling tyre on a static rig. In the past I have done some back-to-back tests with a variety of these tyres, all at the same inflation pressure and on the same car, and found that the results were wildly different. Tyres absorb energy through two mechanisms: conventional damping and hysteresis. Both of these were shown to vary significantly through the frequency range and between different types of tyre. We therefore concluded that the behaviour of a hot, rolling tyre would be more different still.

2.2 Aero

Clearly on a test rig there is no wind, and so aero has no impact. On track, however, the aero forces on the car behave like non-linear springs between the chassis and the ground. As the ride height change, so do the aero forces. At high speeds these effects can dominate ride performance, and even at lower speed have a significant effect. Surprisingly the shape of the aeromap can also either add or remove energy from the car, depending on the aeromap and mode shape of the car oscillations.

2.3 Mass

Cars are rarely provided fully built on a test rig. Frequently the engine, large amounts of bodywork, the floor and much of the hydraulics are missing. These can be compensated for by the addition of ballast, but it is not always easy to achieve correct moment of inertia, weight distribution and mass. Furthermore, the driver is rarely present, so the role the moving mass of the driver plays is not accounted for.

2.4 So what should you do?

The confounding factors discussed above are frustrating, but one very positive factor is that the optimal ride performance tends to lie in a broad range of ‘good’ ride performance, and so although we can rarely achieve perfect ride performance, we can usually achieve something very close to it. The workflow I recommend for ride correlation and improvement is as follows:

1. Put the car on the rig.
2. Ballast the car appropriately to achieve something close to running weight distribution, mass and moment of inertia.
3. Modify the car in your simulation tool to reflect what is on the rig.
4. Run tests on both and attempt to correlate responses and sensitivities.
5. Once correlated, revert the car setup in Canopy to something more closely resembling a running car, then search for ride improvements in simulation, having used the rig primarily as a correlation tool.
6. When running the car at the track respond to specific issues but otherwise have confidence that ride is in the broad range of good performance.

3 Virtual 4 Post

Virtual 4 Post offers a relatively simple tool for ride analysis. There is a choice between running a *Standard Sweep* or a *User Defined Sweep*. The standard sweep goes through the following stages:

1. Heave sweep: wheel pans under the front and rear wheels go through a frequency sweep with front and rear z-displacements equal.
2. Pitch sweep: wheel pans under the front and rear wheels go through a frequency sweep with front and rear z-displacements 180 degrees out of phase.
3. Kerb strikes: the car drives over bump applied only to the left hand side of the car.
4. Symmetrical bump: the car drives over a bump which is left/right symmetrical.

The results of a single sweep typically look like the following: