



A Study into the Damping Properties and Transmissibility Characteristics of WP's Cone Valve Forks

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Introduction

The WP Cone Valve damping system has recently been introduced to the field of motorcycle suspension. Little is known about the system therefore this dissertation explores the physical attributes that each system variable offers to damping force properties, as well as presenting methodology for the determination of perceived ride comfort.

Transmissibility is described as the ratio of magnitudes of displacement or acceleration induced by an excitation force i.e. road irregularities [1]. It was found by Cossalter that a damping ratio of 0.354 provides the least acceleration transmissibility at low frequencies [2].

$$T = \frac{Z_0}{y_0} = \sqrt{\frac{(2\zeta r)^2 + 1}{(1 - r^2)^2 + (2\zeta r)^2}}$$

Project Aims

- To explore the effects of cone angle and valve spring rate on damping force
- Highlight displacement and acceleration transmissibility properties
- Determine an optimal cone valve configuration based on Cossalter's ideal damping ratio

Methodology

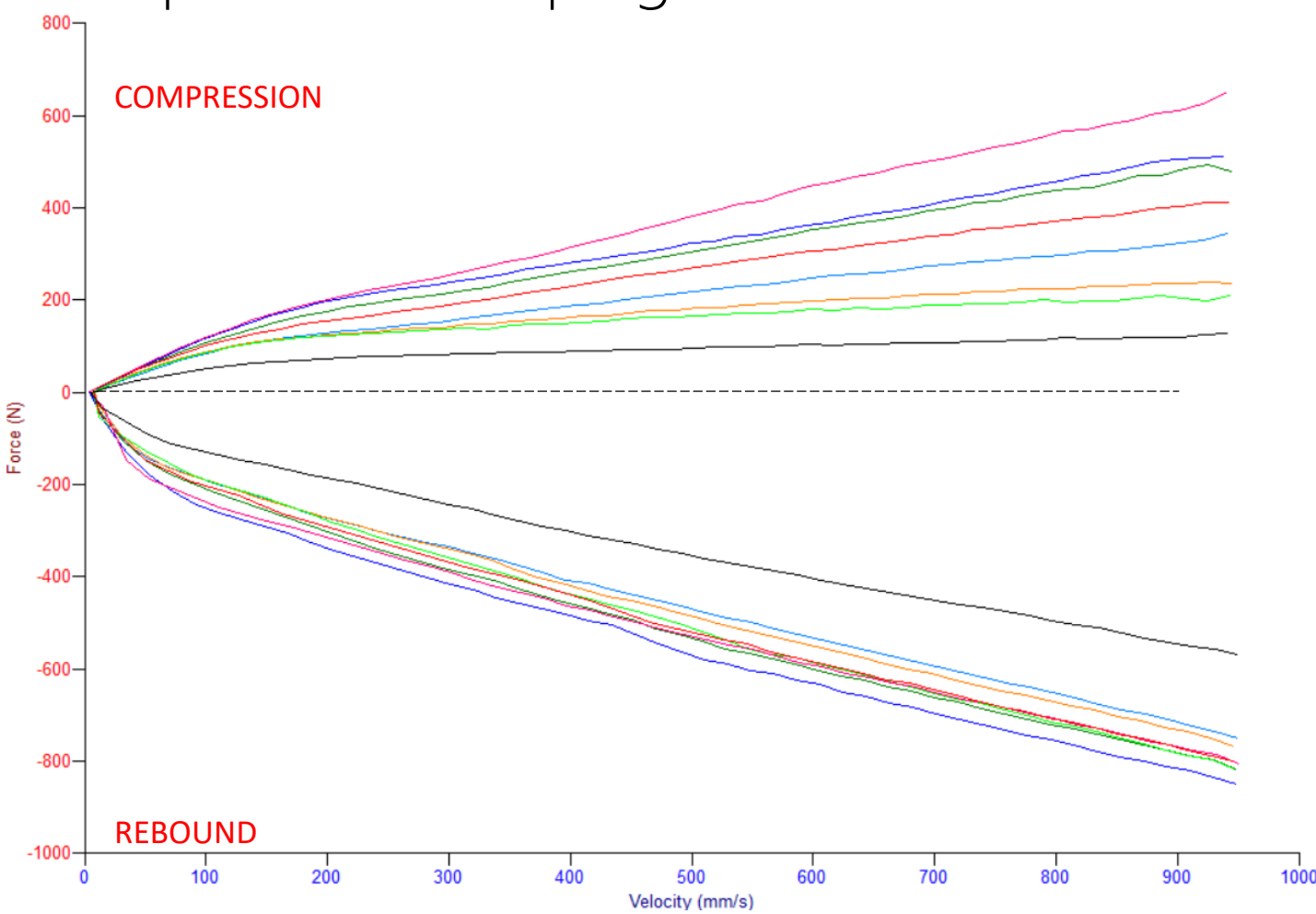
The following valve configurations were tested on a damper dynamometer at speeds up to 1000mm/s.

Table 1: Valve configurations under investigation

Test	Cone °	Cone Spring Rate N/mm
1	18	100
2		25
3		240
4	15	100
5		25
6		240
7	11	100
8		25
9		240

Results

Cone valve spring rate had a higher impact on damping forces than cone angle, whereby increasing spring stiffness drastically increased the gradient of compression damping forces.

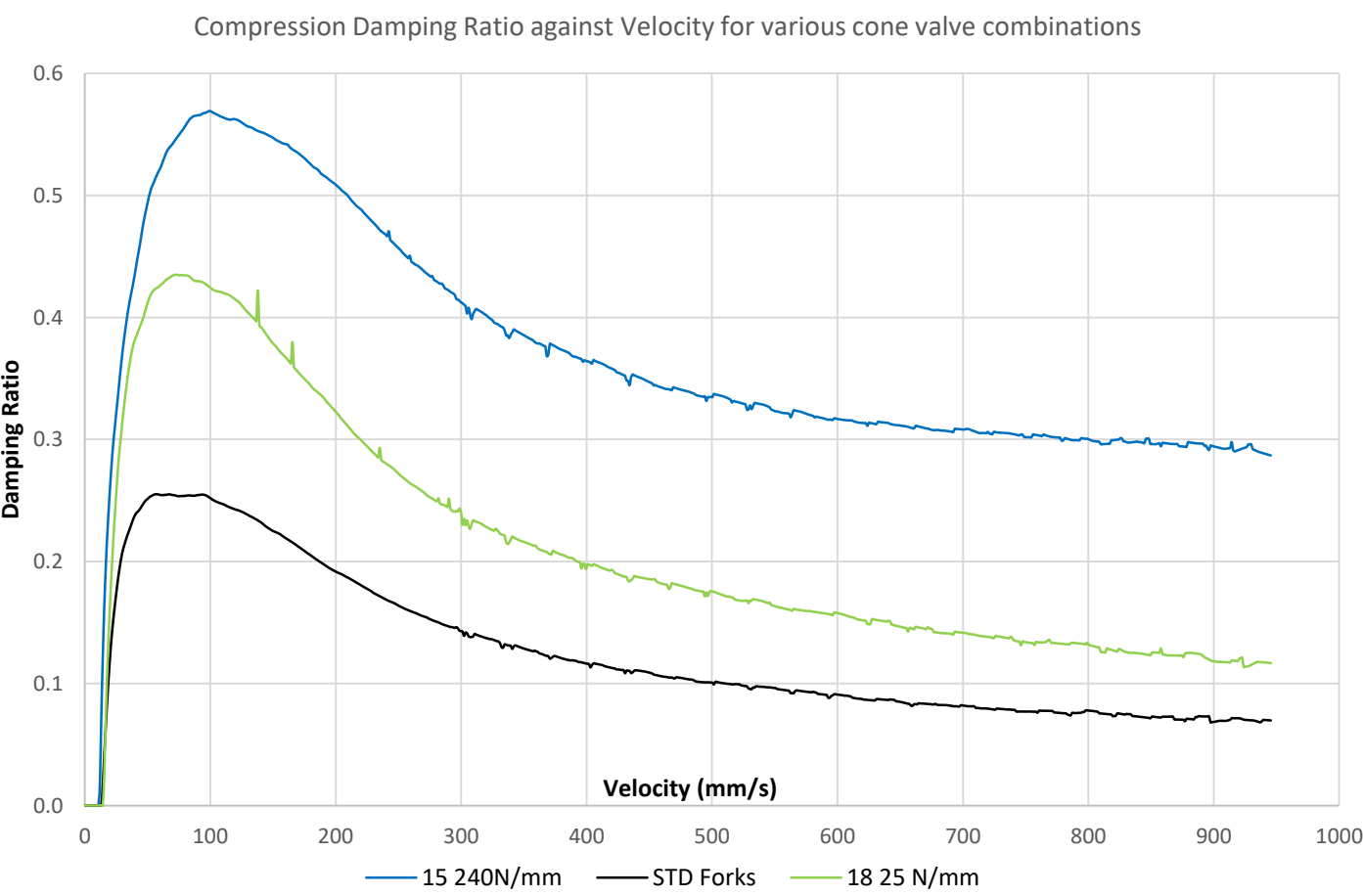


Graph 1: Averaged force-velocity graph showing the tested configurations at 10 clicks of rebound adjustment

The 9 configurations of cone valve and spring rate were further analysed against standard WP forks and post-processed into damping ratio values.

$$\zeta = \frac{c}{2\sqrt{km}} \quad c = \frac{\text{Force}}{\text{Velocity}}$$

The two traces with the largest difference in maximum low-speed and minimum high-speed damping ratios were analysed further against the standard WP forks.

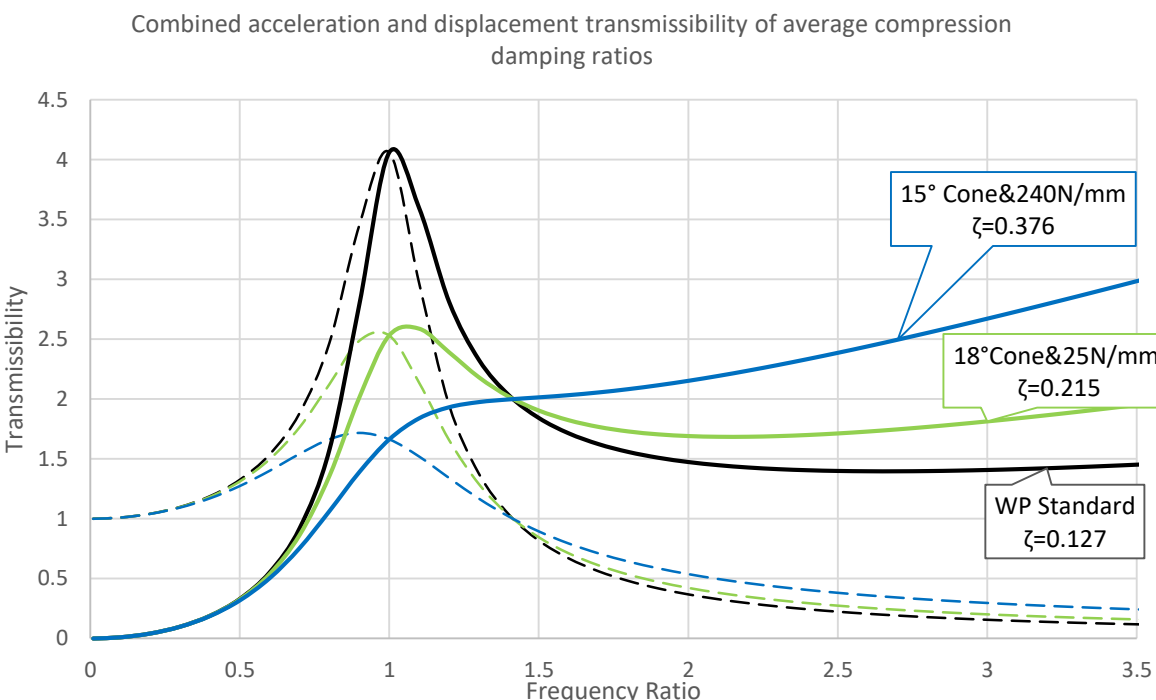


Graph 2: Damping ratio values against velocity with selected data traces

Thus using principles of displacement and acceleration transmissibility, the perceived ride comfort provided by each trace is then analysed.

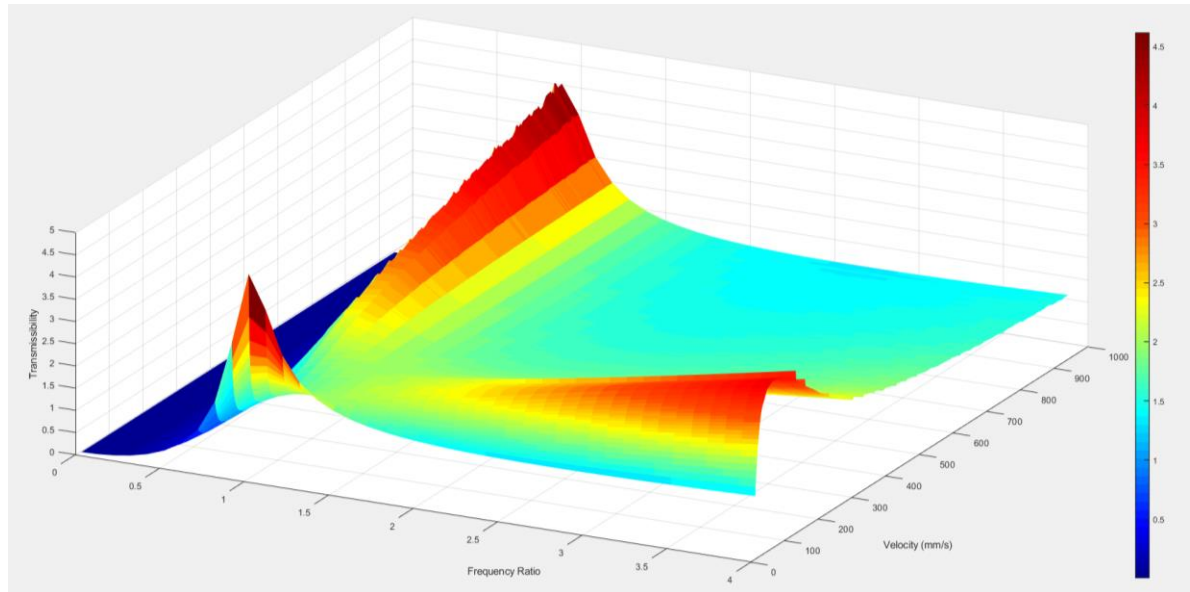
Transmissibility Analysis

Lower damping ratios result in higher amplifications of transmissibility at low frequency inputs and has a negative impact on ride comfort.



Graph 3: Combined transmissibility properties of both displacement (dashed) and acceleration

However at high frequencies higher damping ratios amplify acceleration transmissibility. Thus it was decided that the ideal configuration has a low-speed damping ratio closest to that proposed by Cossalter, and a high-speed ratio as low as possible.



Graph 4: 3D graph of acceleration transmissibility for the 18° cone and 25 N/mm spring

Conclusions

Steeper angled cone valves and stiffer spring rates resulted in higher gradients of compression damping force at mid-to-high velocities.

The 18° cone and 25 N/mm spring provided the best baseline valve configuration to minimise magnitudes of high-velocity and frequency transmissibility, whilst remaining responsive at low-speed.

References

[1] Shaikh, A. M., Yogaraja, V., Shivani, S. & Gupta, Y., 2013. *Optimization of Motorcycle Ride Characteristics – A Holistic Approach*, India: SAE International.
[2] Cossalter, V., 2006. *Motorcycle Dynamics*. 2nd ed. s.l.:Vittore Cossalter.