Design of a Torque Control Strategy for Enhanced Comfort in Heavy Trucks

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In the design of most cars much effort has been made to make the user experience pleasurable. While this is strived for also in the heavy truck industry, certain inconvenient vehicle characteristics exist that make good comfort harder to achieve. This thesis investigates how to prevent these problems from occurring by controlling the engine torque and suggests such a preventive strategy.

In the heavy truck industry, the trademark of the company plays a big role. A certain truck should have a certain feel, behavior and characteristics. What distinguishes a Scania truck as of today can be summarized by the company's three core values; customer first, respect for the individual and quality [1]. With the high cost that a Scania truck implies, only the best of user experiences can be expected.

In a heavy truck the vehicle behavior becomes very different from that experienced in a car. The car's engine is a lot smaller and weaker compared to the vehicle's driveline than that which is placed in a heavy truck. The full weight of the carriage has to be accelerated, which requires a more powerful engine. The components comprising the driveline, especially the drive- and propeller shafts, can however not simply be made stronger in the same fashion when the engine power is increased. When the full torque of the truck engine is applied to the therefore relatively weaker driveline, the axles will twist and bend. This twisting causes oscillations, affecting the cabin of the vehicle and thus the driving experience. An example of such oscillations can be seen in Figure 1.

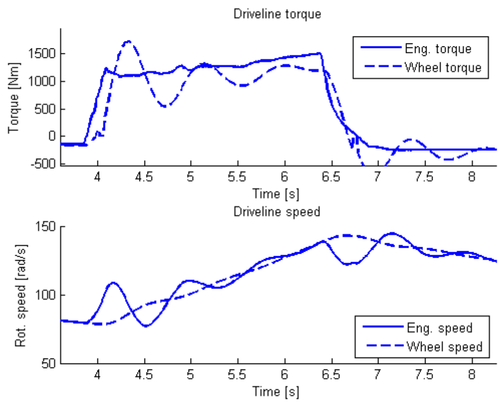

Figure 1 – An example displaying an oscillating wheel torque when no torque control is performed. The wheel torque is the propelling force of the vehicle, and the result is therefore great comfort disturbances.

A solution to this problem can mainly be found in controlling the engine to output torque in a way that prevents these oscillations. To achieve such a goal is a challenging problem, as the driveline also contains other, worsening properties such as backlashes and other nonlinearities. These attributes make approaches such as classical linear control less successful, even though improvements can be seen.

This thesis was initiated in August of 2012 at the Powertrain Torque Control group at the R&D department of Scania's in Södertälje, Sweden. The goal was to investigate how the engine torque could be controlled to prevent the mentioned oscillations and to devise a strategy for implementation in the control unit for the engine.

The approach taken in this work is to first investigate what is possible to achieve when no limitations (for example linearity) is set on the controlled torque and full knowledge of the system is assumed. This is done using optimal control, and an example of such a solution can be seen in Figure 2.

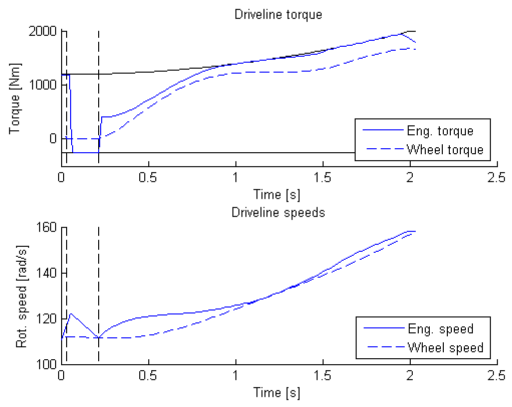

Figure 2 – A result from optimal control, displaying an example of a torque control sequence that achieves maximum torque rapidly, still without oscillations.

These results, combined with some basic intuitivity then lead to a straightforward approach of controlling the engine torque. As the real wheel torque cannot be measured due to the lack of a torque sensor, an approximate wheel torque is instead calculated. Using this calculated value to limit the applied engine torque yields the desired results. As the difference between the two torques in the driveline are now limited, no major oscillation can occur as there is no excess torque to induce such an oscillation. The result is a vehicle providing better comfort.

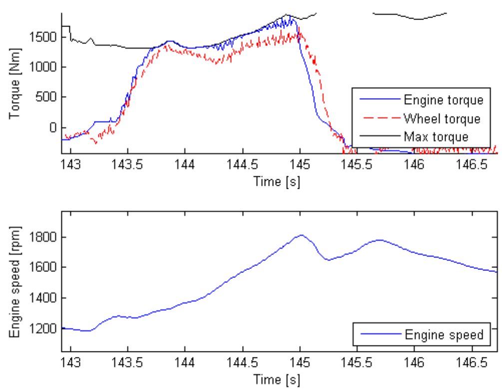

Figure 3 – Vehicle measurements of the suggested strategy. The new strategy is active during times 143.2 and 143.7 s. No oscillation in the wheel torque can be observed.

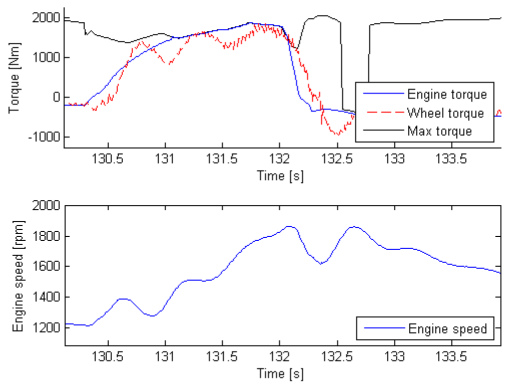

Figure 4 – Vehicle measurements of the current strategy. Too much torque is demanded during the interval 130.3-130.6 s. The result is an oscillating wheel torque.

As can be seen in Figure 3, this simple strategy manages to quickly reach the maximum torque level without inducing oscillations. The same result can be seen in several cases and applications. The goal of the thesis – to prevent the oscillations causing comfort disturbances – can therefore be considered achieved.

References

[1] Scania CV AB. (2013,06,17). *Scania's strategic platform*. [Online]. Available: http://www.scania.com/scania-group/strategic-platform/

[2] Tunhag, J. *Design of a Torque Control Strategy for Enhanced Comfort in Heavy Trucks*. M.Sc. Thesis, Department of Automatic Control, Lund University, Lund, Sweden, 2013.