ELECTRO MECHANICAL DESIGN OF A POWER ASSISTED STEERING SYSTEM

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Motivation

Most modern automobiles would be incredibly difficult to manoeuvre without PAS. Due to factors such as wider tyres, front wheel drive and increased vehicle mass. This has led to the search for more economical and effective systems for steering assistance. The 1950's saw the arrival of the first commercially available hydraulic power assisted steering system. Since then, only minor improvements have been made, nevertheless the general concept has remained the same. However, recently a lot of research is being carried out into eliminating the use of the hydraulic system as it has proven to be significantly uneconomical.

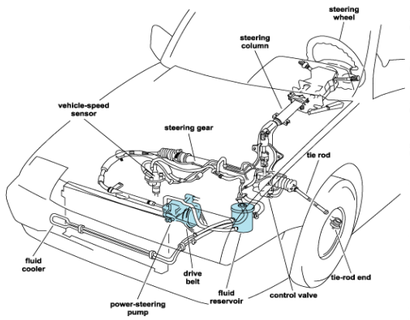
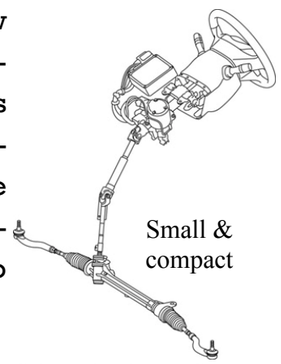


Fig 1:Schematic of a HPS system

Objective

To design and manufacture a new electric power steering (EPS) test rig, using an electric motor for the assistance as opposed to a hydraulic pump. The elimination of the hydraulic pump could save valuable space in the engine compartment, therefore smaller cars could also reap the benefits.



Schematic of an EPS system

Substructuring

"*An approach for real time testing of electro-mechanical components*"

The test rig was built to employ the valuable concept of substructuring. Substructuring is the break down of a convoluted and critical component of a large system into minor and more manageable subcomponents. These can then be tested in real time (physical substructure), whilst the remnants of the system are tested numerically in parallel (numerical substructure).

How it works

Torque is applied by the driver on the steering wheel; this is the input for the system. The steering wheel is connected to the steering shaft via a torsion spring. Two torque sensors are connected to both ends of the torsion bar in order to sense the change in torque due to a difference in angle on both the steering wheel and steering shaft. The steering shaft is connected to an assist motor via a belt-drive system. As the steering wheel is turned, a slight delay in the torsion bar allows the steering wheel sensor to detect a change in angle. This creates an angle difference between the steering wheel sensor and the steering shaft sensor. The difference in angle actuates the assist motor and a control algorithm determines the amount of assistance required; this is the system output.

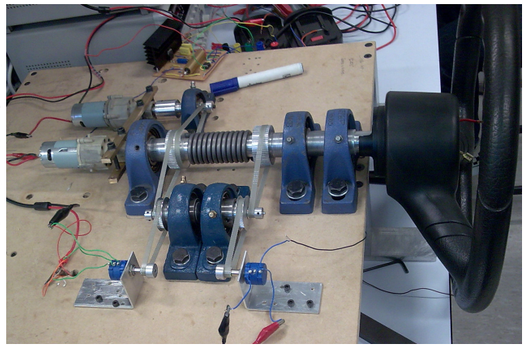


Fig 3: The fully built test rig

Results

A combined test on both the reduction of steering torque controller and the return to centre controller was conducted to analyse the performance of the EPS system. The test was broken down into sub-periods of 5 seconds. Each step below explains the three 5 second intervals shown in the top part of Figure 4 :

1st period(0s - 5s)*: Driver rotate wheel to -72°, hold for 1 second, release to test return-to-centre motion.*
2nd period(5s -10s)*: Driver rotate to +72°, hold for 1 second, release to test return-to-centre motion.*
3rd period(10s-15s): *Sinusoidal motion of amplitude 40° to test reduction of steering torque.*

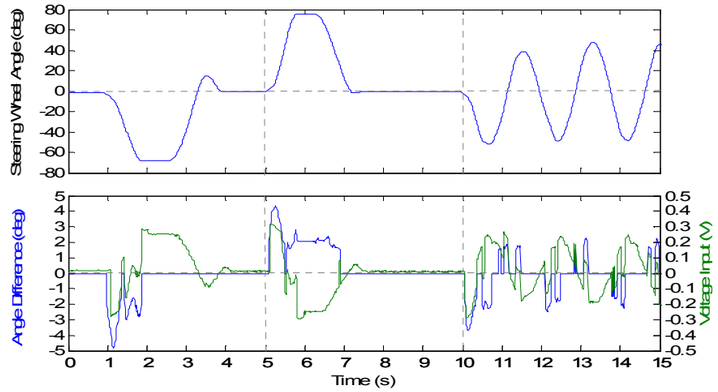


Figure 4: Testing of combined controllers.

The negative voltage and angle difference suggests assistance in the initial counter-clockwise motion. As the driver holds the steering wheel at -72°, the return-to-centre controller kicks in and generates a positive voltage input. As the steering wheel is released, the controller returns the wheel to the central position. The same can be observed in the 2nd period although there is no overshoot, suggesting that the motor has higher damping in the counter-clockwise direction. The voltage input generated throughout indicates a success in performance, as it consistently follows the sign changes in the steering angle difference. Satisfactory feedback is felt by the driver indicating a suitable steering feel.

Further Improvements

The final outcome proved to be a success as it met all project requirements, yet it still held the potential to be improved. However due to time and budgetary constraints, only a CAD model of the improved design was drawn. The theoretically improved design looks into a more compact and realistic model for the rig.