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On-center Steering Response

On-center steering response is one of the important parameters which is closely monitored. It is the measure of steering response during high speed lane change or road maneuverability [24]. It is estimated by measuring the degree to which road wheel turns when steering wheel is rotated by 90° towards LH and RH side. Plot of steering wheel rotation to road wheel turn (R/W) which of existing system and new system is shown in Fig.10 and Fig.11 respectively. Based on the benchmark data it was found that the vehicle handling was found to be better when the steering wheel to road wheel steering ratio is between 20:1 to 26:1. Comparisons of on-center steering response between existing and new design is tabulated in Table 4. It was found that the on-center response of the new design was slightly higher than the existing system. However, both the systems meet the requirement.

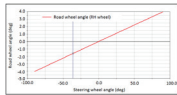


Figure 7: Graph showing steering wheel rotation to road wheel turn in existing design

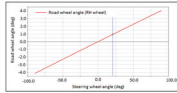


Figure 8: Graph showing steering wheel rotation to road wheel turn in new design

Table 4: Comparison of on-center steering response between existing design and new design

Steering system	On-center steering response	On-center steering response
Existing system	Steering wheel turn	Road wheel turn
Existing system	90°	22.21°
Existing system	-90°	-22.21°
New system	90°	22.71°
New system	-90°	-22.71°

Steering Gear Demand Torque Comparison

An attempt was made to compare the steering gear demand torque values between the existing steering system and new steering system. It is the torque required at the steering gear to turn the road wheel. Load

on the first axle considered for the study was engine torque. Torque required to turn the road wheel about the kingpin was estimated. The type to road forces considered was, $g \cdot 10^4$ kN/m. Kingpin moment was used as a reference torque to determine the steering gear demand torque in the existing and new steering system. For the required design input torque the demand torque from the steering gear was estimated. The kingpin torque and steering gear demand torque value of both the systems are tabulated in Table 5. It can be seen that for the same kingpin torque, the steering gear demand torque has reduced from 4393 N-m to 3277 N-m in the new system which is approximately 25%, lesser than the existing. This will in turn reduce the steering wheel effort to be exerted by the driver to steer the vehicle.

Table 5: Comparison of steering gear demand torque between existing and new system

Condition	Existing system	New system
Engine torque	3300 N-m	3300 N-m
Steering gear demand torque	4393 N-m	3277 N-m

Structural Analysis of Drag Link

Finite element analysis was carried out to study the finite displacement characteristics and modal frequency of the draglink using ANSYS 14.5. FE model of drag link is shown in the Fig.12. Non-linear buckling analysis (one length method) was carried out to estimate the critical buckling load. The boundary conditions defined were, all the three translational degrees of freedom were constrained at one end of tube and it was free to rotate in any direction. At the other end, compressive load was applied along X-axis and other two translational degrees were constrained. It was free to rotate about Y and Z axis but constrained to rotate about X-axis.

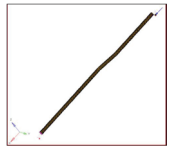


Figure 9: FE model of the drag link

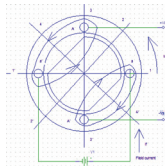


Figure 10: One plane machine with DC motor Excitation

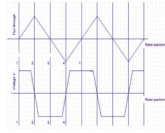


Figure 11: Flux and voltage diagram as a function of rotor position

Let rotor spins with constant speed by external motor in the direction shown in Fig.13. The rotor induces magnetic flux through armature winding from one direction to opposite direction. During one rotor turn it revolves two times. So, the armature voltage frequency is double of rotor frequency system. Fig.14(a) shows flux and voltage wave form as armature coil as a function of a rotor position. This is changing from zero to maximum in armature winding HF during interval between 17° and 22° rotor position. If value of the flux increases linearly from zero to maximum, the voltage wave form is close to rectangular. In interval, between 22° and 33° rotor position, the negative flux flowing through winding HF decrease from maximum to zero. The induced voltage in winding HF change polarity and has the same amplitude. In interval, between position 33° and 44°, the flux changes direction in winding HF and changes its value from zero to maximum in opposite direction. The induced voltage amplitude does not change. In interval, between position 44° and 55°, the flux decreases from maximum to zero. The voltage in armature coil change polarity and has the same maximum value. In the next half period of the rotor rotation, the all processes are repeated. The frequency of output voltage is

$$f = \frac{N}{60} \text{ Hz}$$

f is the voltage frequency in Hz

N is the rotor speed in revolution per minute

The voltage peak depends on the maximum flux (which is proportional to the current excitation) and the rotor speed

$$V = K_a \cdot I_a \cdot \omega$$

I_a is the dc current excitation, and K_a is the constant

Winding a^+ and a^- are identical and can change their functions. This is a Δ can be winding system, and a^+ can be armature winding. If a load is connected to armature terminals, the current will flow in armature coil Fig.15(a). A current carrying conductor in magnetic field produce a force

$$F = I_a \cdot L \cdot B$$

The torque on the armature is

$$T = I_a \cdot L \cdot B \cdot r$$

Where L is the root mean square current flowing in the armature conductors. r is the radial length of the armature wire, I_a is the DC field current, and B is the constant coefficient

In the motor mode operation, the armature current must flow in the direction of existing armature voltage and have direction opposed to voltage drop. That is why, in the motor mode operation, there is a small Δ error of a rotor (voltage) position

If the armature terminal voltage is V_a , the armature resistance is R_a , and armature electromotive force is E , then for a generator mode operation

$$V_a = E - I_a \cdot R_a$$

V_a is the terminal voltage, E is the induced EMF, and I_a is the armature current

R_a is the armature resistance, and I_a is the armature current

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