

UNIQUE GEAR SHIFTING MECHANISM WITH CAM, FOLLOWER & TELESCOPIC ARRANGEMENT FOR TRUCKS

Aravally Patel¹ | G.R.Kesheorey²

¹(M.Tech Scholar, Mechanical Engineering Department, Vindhya Institute of Technology & Science, Indore)

²(Professor, Mechanical Engineering Department, Vindhya Institute of Technology & Science, Indore)

Abstract— In manual driven vehicle, Gear change mechanism is a component that is too often taken for granted but it is one of the most important features of the vehicle. Customer touches, feels the entire vehicle through gear shift mechanism hence it must be quick and smooth in action, efficient and totally reliable. In cab over engine type truck configuration, the mechanical single rod is preferable & is most efficient option for gear shift mechanism. In conventional single rod design one end of Gear shifting linkage is mounted on the engine through bracket and the lever comes inside from the cabin, beside the driver seat for changing the gears. Another end of this linkage is connected to vehicle transmission shift lever. In this conventional design, gear shift lever is having huge induced vibration which is irritating & frustrating in nature. And during the cabin tilting at its axis, a cut out is required on cabin floor which allows cab tilting when GSL is mounted on engine. Sealing this cut out from engine heat, hot air & noise is a challenge. An attempt is made to provide a highly efficient single rod gear shifting mechanisms with telescopic type arrangement, and also it is integrated with a unique cam & follower mechanism to ensure cabin tilting operation at its given axis. This system is independent of the engine placement on the chassis. Also it is vibration free, totally isolated from engine heat & noise as it doesn't require any bigger cut out on cabin floor.

1. INTRODUCTION

Driver comfort inside vehicle cabin during driving is a key factor in vehicle buying decision for long haulage trucks. A gear shifting mechanism is one of the important systems as it directly interacts with driver essentially playing the role of a translator between the driver and the vehicle. It is of paramount importance to have efficient, durable gear shift system in vehicle to provide drivers comfort. There are several types of GSL available in today's commercial automotive industry and all OEM select the type of GSL based on the vehicle packaging & system design constraints. None of the currently available GSL in industry are full filling all the requirements in totality. All are having its own pros & cons.

The various types of gear shifting mechanisms available for use are as follows:

- i. Engine Mounted
- ii. Direct or fixed to Gear box
- iii. Fixed to Cabin with cable type
- iv. Hydraulic type
- v. Servo Shift
- vi. Electronic

2. LITERATURE REVIEW

Design of Single Road Gear Shift Lever System (1)

The gear shift mechanism used in this literature is engine mounted single rod gear shift lever. The single rod gear shift lever (SRGSL) due to relatively simple design and manufacturing and the option of common usage of design across wide range of vehicles.

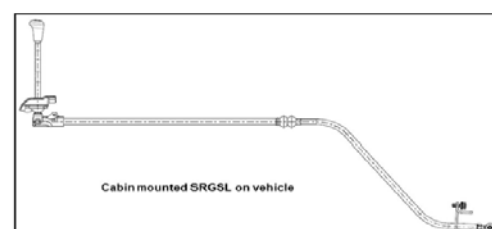
The design process for SRGSL system also has to incorporate certain manufacturing related aspects as these aspects directly influence functioning and operation of the SRGSL system. The tolerances considered for shifting rod manufacturing is to be considered as a high variation from

the intended design requirement could lead to inadequate amount of stiffness in the SRGSL system. This can lead to variation of problems ranging from operator fatigue to complete system malfunction due to component failure. It is also equally important to consider surface treatment and finishing especially for joint locations for linkages.

The critical design requirements for shifting rod used in SRGSL system under consideration for this correlation are as follows: The Shifting rod sub assembly should be free from chips, burrs, scales, etc. The tolerance for shifting rod should be as per specification. The shifting rod sub assembly should be corrosion resistant for at least 480 hours. The type of coating required is powder coating, the tube material should have strength equal to or greater than ERW-1.

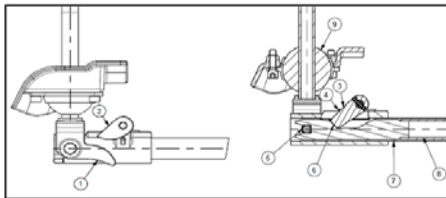
3. METHODOLOGY

All the constraints of existing available gear shifting mechanism are overcome by providing the cabin floor mounted single rod type gear shift mechanism where one end is mounted on the cab floor directly and another end is connected to the Transmission (T/M lever) lever. (Fig.1). And unique cam and follower mechanism is provided to disintegrate & integrate two rods automatically during cabin tilting operation & retaining its original position during cabin down operation.



4. DESCRIPTION OF THE SYSTEM

The GSL is directly mounted on the cabin floor, hence this arrangement is independent of engine placement on the vehicle. Also engine vibration & hot air is fully isolated since this system is directly mounted on the cabin floor. To facilitate cab tilting a unique concept of cam & follower mechanism is introduced. (Fig.2). During cabin tilting the cam uplifts the follower which is directly connected to the interlock mechanism. This interlock mechanism locks the outer hollow rod and inner rod with its ramp & wedge profile (Fig.2)



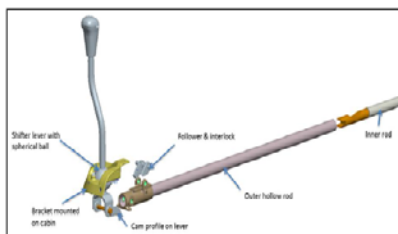
To facilitate gear shifting operation, a pin is provided on the bottom part of shifter lever which pushes the inner rod at its slot profile enabling the forward gear shifting and interlock provided at the outer hollow rod locks the inner rod at its ramp profile and pulls the inner rod enabling the backward gear shifting.

This interlock is loaded with a spring to ensure the contact of interlock with inner rod during vehicle driving condition.

The inner rod is provided with wedge profile on its top for backward gear shifting & a slot profile in its front for forward gear shifting and for gear gate selection.

The single rod is made into two-piece rod in rod construction (Fig.3) which works like telescopic tube during cabin tilting operation.

Spherical type ball joint is provided on the floor mounted lever with optimized lever diameter and spherical joint angle to ensure that all gears are shifting and spherical joint is not getting lock in any gear condition. Also spherical joint is optimized in such a way that gears are not popping out/ jump out in any type of vehicle driving conditions.



5. RESULTS AND DISCUSSION

Modal Analysis

Vibrations play a critical role in vehicle, since the subcomponents are mounted on various vibrating systems. So the most fundamental requirement is to check the model for its natural frequency whether it is within the CAE acceptable limits or not. The simulation results for modal analysis show that the obtained first natural frequency 60.16 Hz is higher than the target frequency of 30 Hz for cabin mounted applications. This would prevent the system from excitations coming from cabin.

Static Analysis:

The static analysis is performed to check the strength of the components in new telescopic SRGSL system. Since the system is subjected to various loads and operating conditions, it is mandatory to measure the stresses and deflections of the system. The summary of stresses and deflection for the static analysis is shown below in table no.1.

Load Case (Static Analysis)	Displacement (mm)	Accept. Displacement (mm)	Von-mises Stress (MPa)	Fatigue FOS	Accept. FOS
Gear Shifting (20 Kg)	0.036	0.7	105	1.7	1.0
Gear Selecting (20 Kg)	0.013	0.7	150	1.2	1.0

Table no.1 – Static Analysis Results Summary

The deflection at the joint locations is below 0.7 mm target as per standards. The deflection at knob locations are also below the target values of 25 mm. Since the shift and select loads in the operating conditions are subjected to alternating loads the stresses obtained in the analysis must be below the endurance strength of the materials. The summary shows that the stresses are below the endurance strength of the material. Hence it is safe from structural point of view as well.

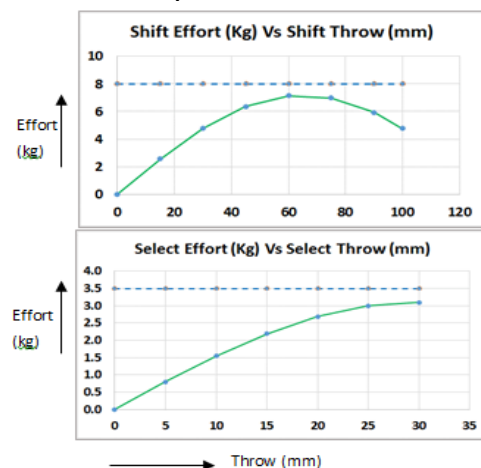
Frequency Response Analysis

The model is further checked by performing frequency response analysis. The mounting points are given excitations in the range of 20 Hz to 150 Hz with 2g excitation in Vertical, Longitudinal and Lateral directions, since one end of the SRGSL system is mounted on gear box which could excite with engine frequencies. So a time domain study is carried out and see the stress behaviours of the system. The stresses computed are again below the endurance strength of the material. The Stress summary for MFR Analysis is shown in table no 2.

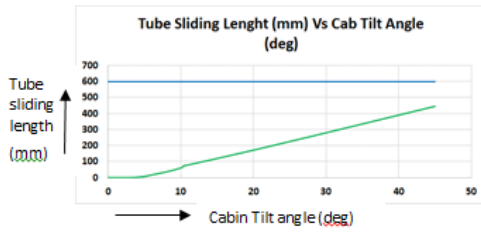
TABLE NO. 2 – FREQUENCY RESPONSE ANALYSIS RESULTS SUMMARY

Load Case (Frequency Response Analysis)	Von-mises Stress (MPa)	Fatigue FOS	Accept. FOS
2g Vertical Excitation	135	1.3	1.0
2g Longitudinal Excitation	140	1.3	1.0
2g Lateral Excitation	160	1.1	1.0

Shift & Select travel optimization



Telescopic mechanism length calculation



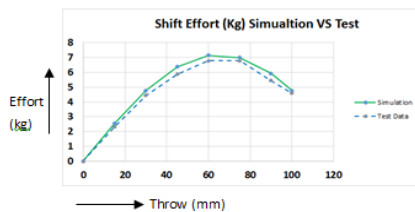
Relative motion simulation

Powertrain Displacement Direction	Displacement: Powertrain (mm)	Rotation Of Gear Lever (deg)	Rotation Of TM Shift Lever (deg) (fixed type cabin)	Rotation Of TM Shift Lever (deg) (2 point suspended cabin)	Target Rotation Of TM Shift Lever (deg)
Vert Up	20	4	0.04	0.5	<4.5 deg
Vert Down	20	4	0.04	0.4	<4.5 deg
Long Fwd	15	10	0.5	0.5	<4.5 deg
Long Back	15	11	0.3	0.5	<4.5 deg
Lat Right	30	0.1	0.01	0.1	<4.5 deg
Lat Left	30	0.2	0.09	0.1	<4.5 deg

6. CONCLUSION

A unique and innovative design concept of gear shifting mechanism is developed which eliminates the effect of cabin tilting on the operation of the SRGSL. The kinematics of system is done in Adams for all driving conditions & Numerical analysis also done. The system is successfully validated for its function on vehicle physically. Same system can be used for cowl type trucks also without tilt mechanism.

Below are the actual vehicle data for shift effort & throw, approx. 92% correlation achieved with respect to simulation results.



REFERENCES

- [1] Naveen Tripathi & Suresh kumar K “Design & Development of SRGSL for HD commercial vehicles with experimental correlation” -16CV- 0003/2016-01-8067
- [2] Creo Software 3.0 help
- [3] Altair – Hypermesh help