Design and performance Analysis of a 5 Speed Manual Transmission System for Indian drive cycle

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ABSTRACT: The manual transmission system in the vehicle has few disadvantages and it can be improved by adopting various methods and also it can be improved if the number of gear ratios and their stepping are wisely selected. The few important parameters such as the vehicle performance, fuel consumption and pollution rate can be improved by varying gear ratios in the transmission. Hence there is a need for designing transmission with optimal gear ratio which gives best performance and low fuel consumption. The five speed manual gear box with higher overall gear ratio and finer stepping of gear ratio are adopted for medium sized cars for fuel economy reasons. The performance improvement can be done by the selection of intermediate gear ratios. Many gear ratio sets for a selected car are obtained by varying final drive ratios, intermediate gear ratios and gear stepping with respect to Indian traffic pattern and Speed requirement in each gear. The performance test is carried out in ADAMS CAR for all the obtained gear ratio sets and also for the existing car transmission gear ratios. Later, comparisons are made between them and optimal gear ratio set for achieving better performance is selected.

K**eywords: Manual transmission system, final drive ratio, 5 gear positions.**

I. INTRODUCTION

This paper proposes new way of finding gear ratios of the selected Manual transmission systems are characterized by the ratios of the gear and that can be selected by locking the gears to the output shaft inside the transmission. For maximum speed, the higher gear (5^{th} gear) can be selected but the engine power and fuel economy will limit. Lower gear (1^{st} gear) is selected to get maximum speed at maximum gradient. The intermediate gears provides smooth gear shift from first to top. For the design of transmission gear ratios for a particular application, the first step is to calculate first and final gear ratio based on vehicle and performance requirements. The vehicle parameters include mass of the vehicle, maximum power at engine rpm, maximum torque at engine rpm, vehicle wheel diameter, and final drive ratio and the performance requirements include maximum speed, grade ability, and efficiency of power transfer. Solid works is a powerful 3D modelling application software. It is best for capturing the design intent of any physical model.

II.PROBLEM STATEMENT

It is determined that the manual transmission provides a higher rate of acceleration in first gear but a low top speed near the engines redlines than the automatic transmission. This information provides useful data for determining the advantages and disadvantages of different types of transmission. The automatic transmission cannot provide higher rate of acceleration, gears are automatically changed and cannot give better efficiency. According to Indian traffic the automatic transmission system cannot provide less fuel consumption.

III.OBJECTIVES

- The scope of 5 speed manual transmission system in Indian market.
- To obtain gear ratios of Lamborghini car manual transmission system using appropriate method.
- Simulation of the car using ADAMS to carry out performance analysis under various conditions.
- To arrive at the optimal gear ratios to achieve better performance.

IV.LITERATURE SURVEY

Panhard-Levassor [1] presented the whole drive train layout. It has made as prototype that can be used for most vehicles which are built in the 90's. It was included with an engine vertically mounted at the front which will drive the rear wheels with the help of a clutch, three-speed sliding gear system and axle with chain-driven mechanism. But a new feature missing in this setup was rear differential axle with a driveshaft.

Cadillac [2] introduced a synchronizing transmission system which will let the driving and driven gear system to mesh each other without any gear clashing. This setup made it possible to for the gears to come to the same speed before engage. Today, this design was patented by Porsche is widely used today.

Walter Wilson and Irene Michelle Berry [3] introduced "planetary manual transmissions", this gear mechanism, has 4 separate planetary gears, and the driver gear was allowed to preselect ratio of the gear by sliding a small lever which is on the steering column. Then the driver can allow the preselected gear with the help of foot pedal which will disengage one gear and engage the preselected gear set.

V.METHODOLOGY

- Scope of manual transmission system in Indian market
- Assuming the segment and class of vehicle and maximum speed at level road and gradient
- Building the car model using ADAMS, alter the gear ratios, final drive ratio, gear steps and obtain acceleration performance.
- Based on the performance the better performance is achieved.

VI.MATHEMATICAL MODELLING

Wheel diameter in m

Rw= $\left(\frac{tyre\ width\ X\ aspect\ \ ratio}{100}\right) + (Rim\ diameter\ X\ 25.4)$
= 0.3
Overall gear ratio of final gear = $\frac{3.6 \times \pi \times N_{emax} \times R_w}{30 \times V_{max}}$
= (3.6*3.14*5800*0.3) / (30*150) = 4.370
Gear ratio of final gear,

$$N_{tg5} = \frac{\text{Overall gear ratio of final gear}}{N_{fd}}$$

= 4.37 / 4.8 = 0.89
Overall gear ratio of first gear = $\frac{(F_r\ cos\theta + sin\theta) \times W \times R_w}{T_e \times \eta_t}$ = 17.8

Gear step, $\emptyset = \sqrt[n-1]{\frac{n^{th}\ gear\ ratio}{1^{st}\ gear\ ratio}}$
= 0.67
Gear ratio of 2nd gear , $N_{tg2} = N_{tg1} \times \emptyset$
= 3.72 * 0.67 = 2.50
Gear ratio of 3rd , $N_{tg3} = N_{tg2} \times \emptyset$
= 1.65
Gear ratio of 4th gear, $N_{tg4} = N_{tg3} \times \emptyset$
= 1.10
Gear ratio of 5th gear, $N_{tg5} = N_{tg4} \times \emptyset$
= 0.73

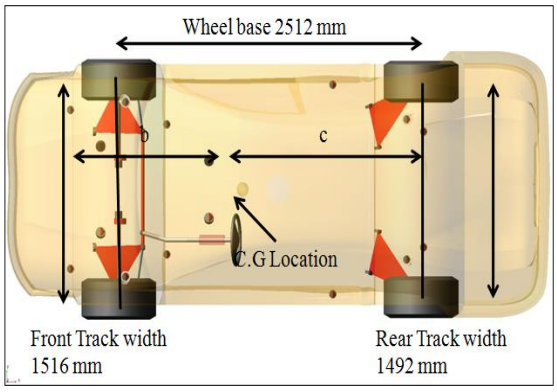

Fig 1: Lamborghini car wheel base and track width model

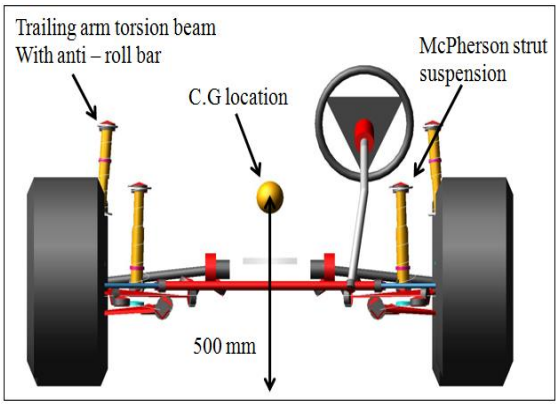

Fig 2: Power train specifications

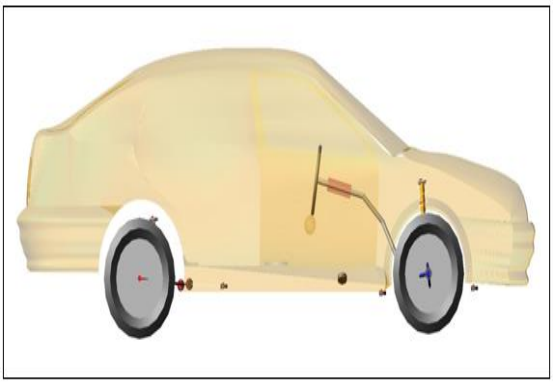

Fig 3: Complete assembly model

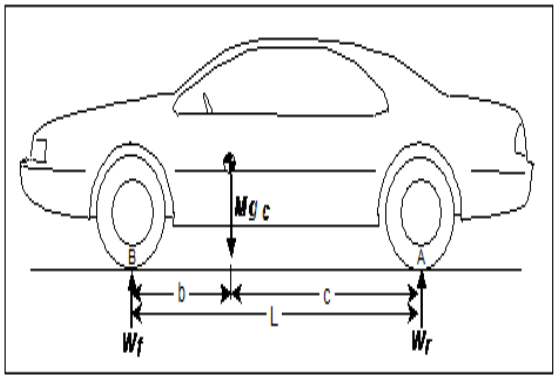

Fig 4: Weight distribution in the vehicle

We know that,

Wrs = W * 52% = 1750 * 0.52 = 910 kg
Wfs = W * 48% = 1750 * 0.48 = 840 kg
B = Wrs * (L/W) = 1306 mm
C = Wfs * (L/W) = 1205 mm
Front area of the car (Af)
Af = The cross section area of the car
Af = 0.8(width * (Height- Ground clearance) + (Tyre width * Ground clearance *2)) = 0.8(1475 * (1800 – 160) + (155 * 16 * 2)
= 2.46m^2

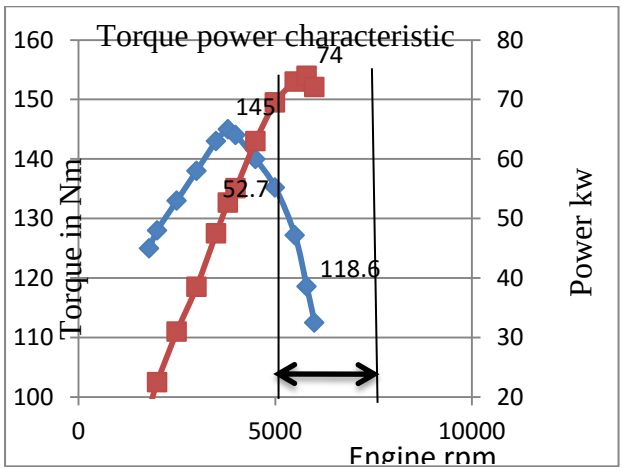

Fig5: Engine characteristics curves

Road testing According to Indian traffic pattern

The road testing has done to understand the Indian traffic pattern and vehicle speed requirement in each gear. The velocity of the vehicle is noted down for every 5 second.

VII.PROBLEM SOLVING

Performance analysis of the Skoda auto sports car using MSC.ADAMS

The simulation and analysis of acceleration performance has carried out using ADAMS / CAR software. ADAMS helps to build and test functional virtual prototypes of complete vehicle and vehicle subsystems.

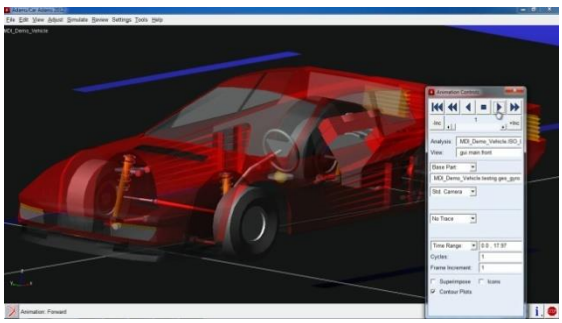

Fig6: Simulation diagram of acceleration performance

The simulation diagram of acceleration performance is shown in figure3.12. Acceleration test is carried out for the above car with under various conditions such as:

1) By varying the final drive ratio
2) By keeping 1st and 2nd gear wider
3) By keeping 3rd and 4th gear closer
4) By keeping 4th and 5th gear wider.

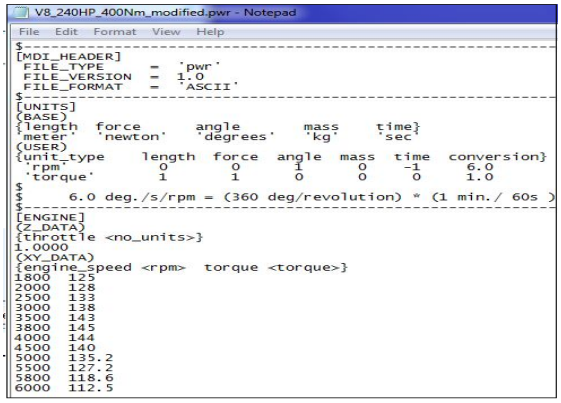

Fig7: Engine torque vs speed data

VIII.RESULTS AND DISCUSSIONS

Design for better acceleration Performance

Table1: Case 1: Gear ratios – speed vs time data with final drive ratio as 4.467:

Sl No	Gear Position	Maximum Speed(m/s)	Time (s)
1	1st	15	14
2	2nd	26	22
3	3rd	40	31
4	4th	55	42
5	5th	65	50

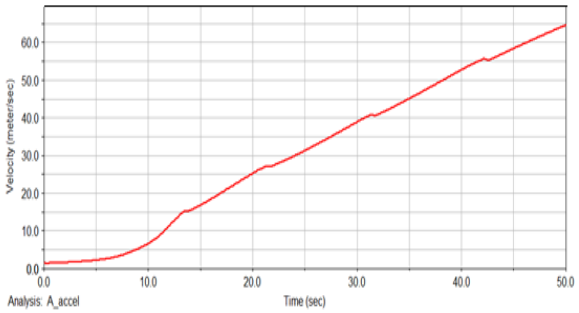

Fig8: Acceleration Performance with Final Drive Ratio as 4.467

Table 2: Case 2: Gear Ratios – speed vs time data with final drive ratio 4.8

Sl No	Gear Position	Maximum Speed (m/s)	Time (s)
1	1st	15	5
2	2nd	25	10
3	3rd	38	20
4	4th	53	34
5	5th	65	46

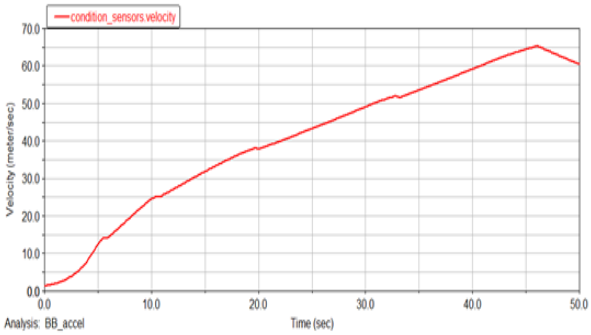

Fig9: Acceleration Performance with Final Drive Ratio as 4.8

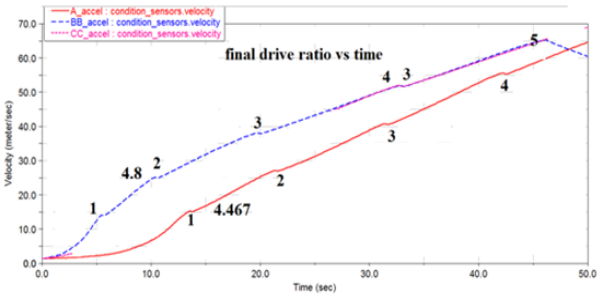

Fig 10: Comparison graph with various final drive ratios

Final drive determines the ratio of how many revolutions the driveshaft makes to turn the tires one turn. So, if the final drive ratio of 4.467 then that means for every 4.467 turn of the drive shaft the wheels will do one full turn. If we raise final drive ratio, it increases acceleration but lower gas mileage. The engine size, torque, horsepower and weight, play a part in determining final drive ratio.

If the final drive ratio is 4.467, then.
4.467 = (0.377 * (0.377) * 5800 / Engine rpm
Maximum speed = 185 km/h
Engine rpm = (65 mph * 4.467 * 336) / 30
= 3251 rpm

If the final drive ratio is 4.8, then.
4.8 = (0.377 * (0.377) * 5800) / Engine rpm
Maximum speed = 170 km/h
Engine rpm = (65 mph * 4.8 * 336) / 30
= 3494 rpm
Also, the torque available in the 1st gear is 145 Nm and the wheel torque will be
(145 * 3.72 * 4.467) = 2409 Nm
If we change the final drive ratio to 4.8 then the wheel torque will be
(145 * 3.72 * 4.8) = 2589 Nm

There is a increasing in wheel torque and gives better acceleration.

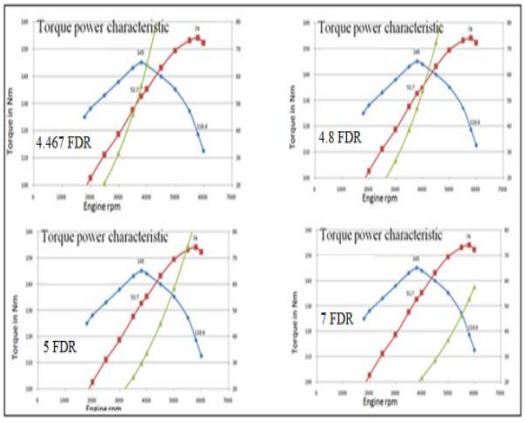

Fig 11: Comparison graph 2 with various final drive ratios

By changing the final value, various vehicle designs can be obtained. The three different designs are:

- Maximum performance design
- Over revving design
- Under revving design

Case 3: Increase First Gear Ratio from 3.72 to 4.2
If the gear ratio increases from 3.72 to 4.2 then, the engine speed will increase which results in more acceleration and leads to bad fuel economy.
Case 4: Decrease First Gear Ratio to 2.5
If the gear ratio reduced from 3.7 to 2.5 than, the engine speed will reduces which results in less acceleration.
Case 5: Wider Fourth and Fifth Gear ratio

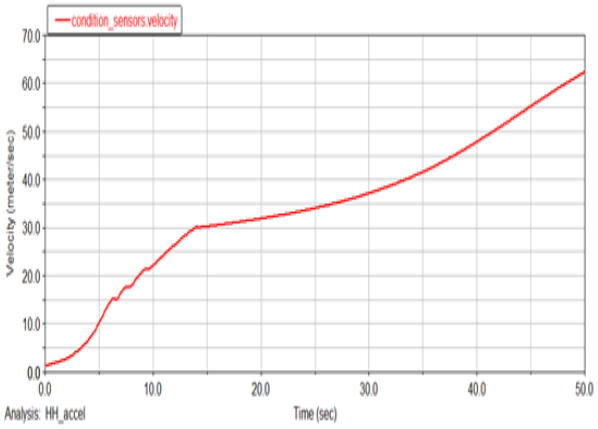

Fig 12: Acceleration Performance with wider Fourth and Fifth Gear Ratio

Reducing the progression between 3rd and 4th gear changes the 4th gear ratio from 1.10 to 1.2. Thus, when the engine speed reaches 5800 rpm in 3rd gear and 4th gear will reduce the engine speed to 4218 rpm and this speed range is near the maximum power line but increasing in the acceleration can reduce the fuel economy of the engine.

Comparison of acceleration performance

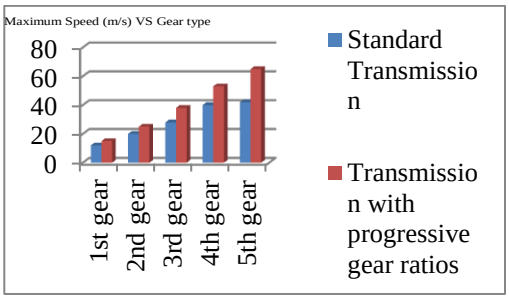

Fig13: The comparison study has done based on time to reach particular speed and maximum speed of the vehicle.

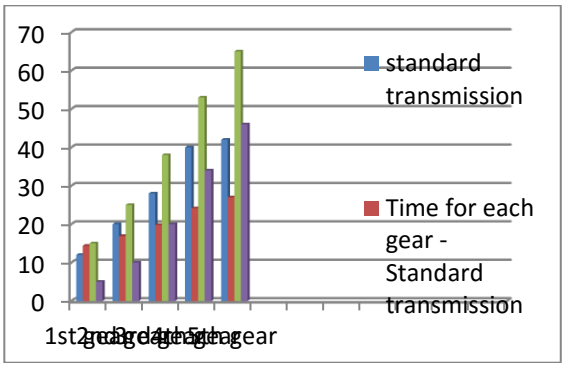

Fig 14: Maximum speed in each gear vs time taken graph for standard transmission and transmission with progressive gear ratio.

It can be seen that, the transmission with progressive gear ratios will give better performance compared to standard transmission with better fuel economy.

IX.CONCLUSION

Developing vehicle with good acceleration performance and fuel economy is the major goal of all the OEM's. Thus the transmission has significant effect on acceleration performance of the vehicle, it is important to design and develop perfect transmission system with suitable gear ratios. The virtual simulation tool facilitate to analyze the performance of the system and it reduces the development risk, cost and time.

SCOPE OF FUTURE WORK

In few years the below mentioned technologies could be developed soon:

- Gasoline direct injection engines (GDI)
- Integrated starter-generator,
- Continuously variable transmission (CVT)
- Six and seven gear transmission on larger vehicles.

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