Title : Car Gear System

Objective : Investigate the force conversion in the gear system

Scope : Low rev engine match with five speed manual transmission
Low rev engine match with four speed-auto transmission

LITERATURE REVIEW

Without a transmission, cars would be limited to one gear ratio, and that ratio would have to be selected to allow the car to travel at the desired top speed. If you wanted a top speed of 80 km/h, then the gear ratio would be similar to third gear in most manual transmission cars. For example, if a driving using the third gear at initially there are no acceleration and the engine will screaming. So the transmission uses gears to make more effective use of the engine's torque, and to keep the engine operating at an appropriate speed. Otherwise, the gear system was designed for the smooth and comforted for the drivers. The suitable gear ratio matching will be effectiveness for the fuel consumption and save our environments. There are two type of the gear system available at car. The first system is manual transmission and automatic transmission. Main function of the system is used for force conversion from crank shaft and transfer the torque to the drive train. The drive train will drive the tyres. The key difference between a manual and an automatic transmission is that the manual transmission locks and unlocks different sets of gears to the output shaft to achieve the various gear ratios, while in an automatic transmission, the same set of gears produces all of the different gear ratios. The planetary gearset is the device that makes this possible in an automatic transmission. The automatic transmission using the epicyclic gear.

Latest technology for the transmission would be so flexible in its ratios that the engine could always run at its single, best-performance rpm value. That is the idea behind the continuously variable transmission (CVT). A CVT has a nearly infinite range of gear ratios. In the past, CVTs could not compete with four-speed and five-speed transmissions in terms of cost, size and reliability. These days, improvements in design have made CVTs more common. The differences name of the CVTs based on the manufacturer. The CVTs technology deliver the Tiptronic gear system. A tiptronic is a type of automatic transmission that allows driver flexibility and control by adopting some of the advantages of a manual transmission. A tiptronic gearbox allows the driver to override the automatic mode for better control of performance. Other type of CVTs technology is sequential manual gearbox. A Sequential Manual Gearbox is a transmission which allows the driver to select the gear either directly above or below the gear which is currently in use by pulling or pushing a paddle or lever. This type of transmission is useful in high performance and racing cars.

Until recently, the CVT has experienced difficulty integrating into the marketplace, but with advances in technology in the latest models of car this type of transmission is more user-friendly and is becoming a common alternative to the manual or automatic transmissions.

RESEARCH METHODOLOGY

Introduction

The research methodology defines what the activity of research is, how to proceed, how to measure progress, and what constitutes success. The main purposed of the research is to investigate the force conversion in the gear system at low rev engine with manual transmission and automatic transmission. Data for this research were collected through internet, sale broachers and observation.

Research instruments

This research utilized in quantitative and qualitative research methodology. The instruments used to collect data were internet surfing, sale broachers and observation. Internet surfing and sale broachers were to find the car specs. The qualitative data for this research is come from observation of the gear system.

Research Procedure

Before the actual data collection period, a pilot study was conducted to asses the validity of the research instrument. The group members were involved in the pilot study to find the car specs in internet and sale broachers.

Data Analysis

To analyze the data, a total of two variables were taken into the consideration namely low rev engine with manual transmission and low rev engine with automatic transmission. Data were calculated to find the output result from the gearbox. The calculated method is using a manual and Microsoft Excel to get the data and graph plotting.

FINDING AND DISCUSSION

1. Design concept and analysis

The transmission is place between the engine and the drive shaft. The transmission is connected through the clutch. The figure 1 shows the basic concept where are the gearbox place in the car system.

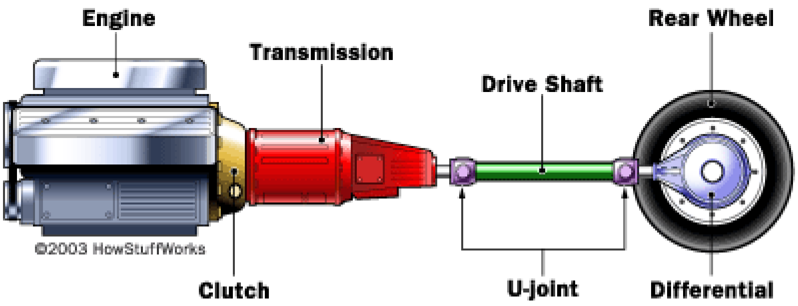


Fig. 1

1.1 Manual transmission

To understand the basic idea behind a standard transmission, the Figure 2 shows a very simple two-speed transmission in neutral:

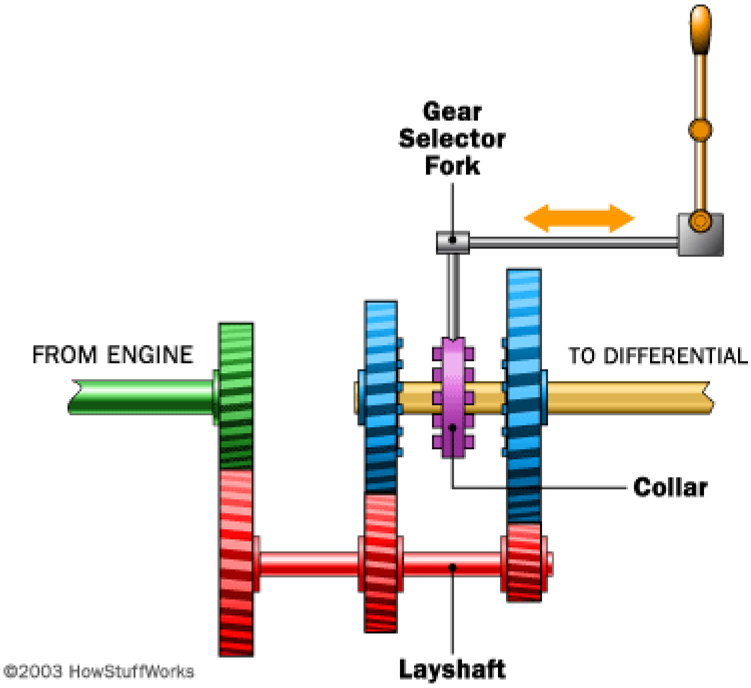


Fig 2

Observe at each of the parts in this diagram to understand how they fit together:

- The green shaft comes from the engine through the clutch. The green shaft and green gear are connected as a single unit. (The clutch is a device that lets you connect and disconnect the engine and the transmission. When you push in the clutch pedal, the engine and the transmission are disconnected so the engine can run even if the car is standing still. When you release the clutch pedal, the engine and the green shaft are directly connected to one another. The green shaft and gear turn at the same rpm as the engine.)
- The red shaft and gears are called the layshaft. These are also connected as a single piece, so all of the gears on the layshaft and the layshaft itself spin as one unit. The green shaft and the red shaft are directly connected through their meshed gears so that if the green shaft is spinning, so is the red shaft. In this way, the layshaft receives its power directly from the engine whenever the clutch is engaged.
- The yellow shaft is a splined shaft that connects directly to the drive shaft through the differential to the drive wheels of the car. If the wheels are spinning, the yellow shaft is spinning.
- The blue gears ride on bearings, so they spin on the yellow shaft. If the engine is off but the car is coasting, the yellow shaft can turn inside the blue gears while the blue gears and the layshaft are motionless.
- The purpose of the collar is to connect one of the two blue gears to the yellow drive shaft. The collar is connected, through the splines, directly to the yellow shaft and spins with the yellow shaft. However, the collar can slide left or right along the yellow shaft to engage either of the blue gears. Teeth on the collar, called dog teeth, fit into holes on the sides of the blue gears to engage them. (2009 HowStuffWorks, Inc.)

1.1.1 <u>First Gear</u>

- Figure 3 shows how, when shifted into first gear, the collar engages the blue gear on the right:

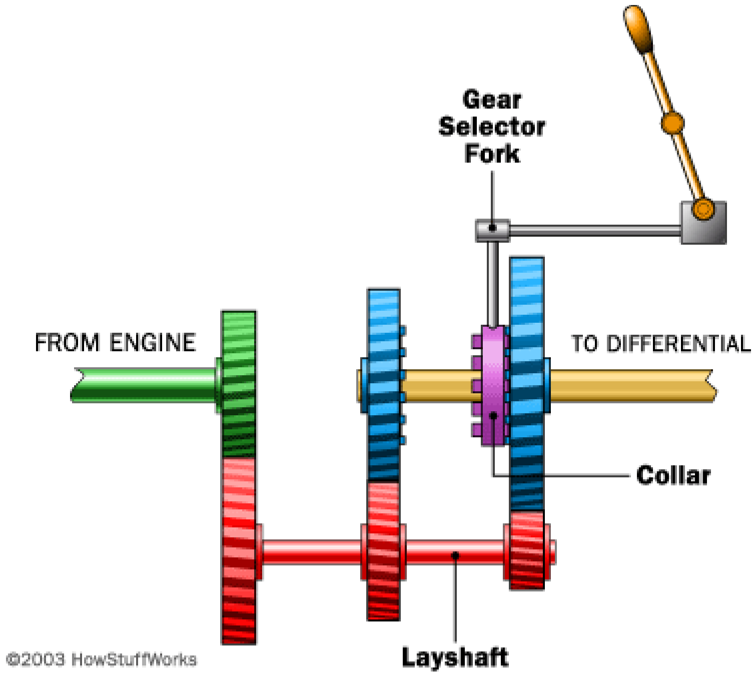


Fig. 3

- In this picture, the green shaft from the engine turns the layshaft, which turns the blue gear on the right. This gear transmits its energy through the collar to drive the yellow drive shaft. Meanwhile, the blue gear on the left is turning, but it is freewheeling on its bearing so it has no effect on the yellow shaft.
- When the collar is between the two gears (as shown in the first figure), the transmission is in neutral. Both of the blue gears freewheel on the yellow shaft at the different rates controlled by their ratios to the layshaft. (2009 HowStuffWorks, Inc.)

The 5 speed manual transmission for standard on car today. The internally look like the figure 4. Gear knob inside the car is used to shift the gear.There are three forks controlled by three rods that are engaged by the shift lever. Looking at the **shift rods** from the top, they look like this in reverse, first and second gear:

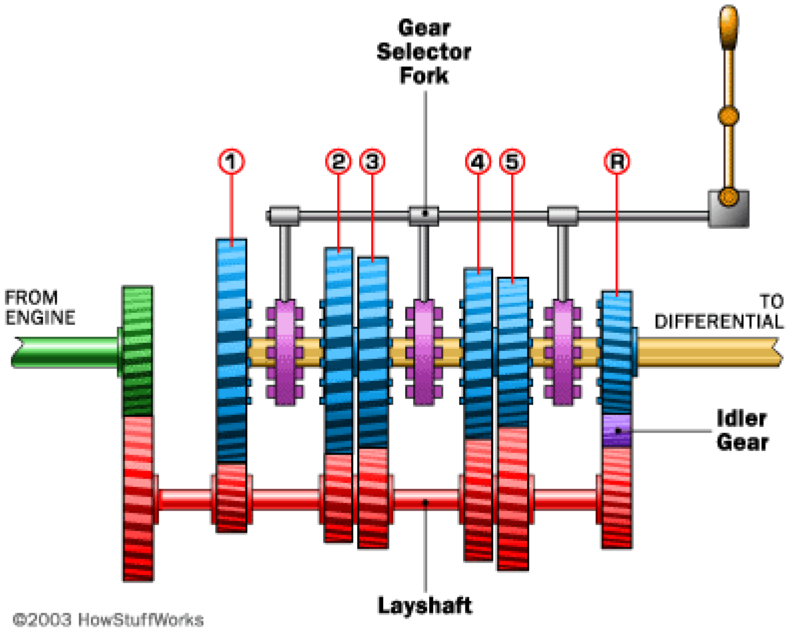


Fig. 4

The real manual transmission diagrams for the today show in **Fig 5**.

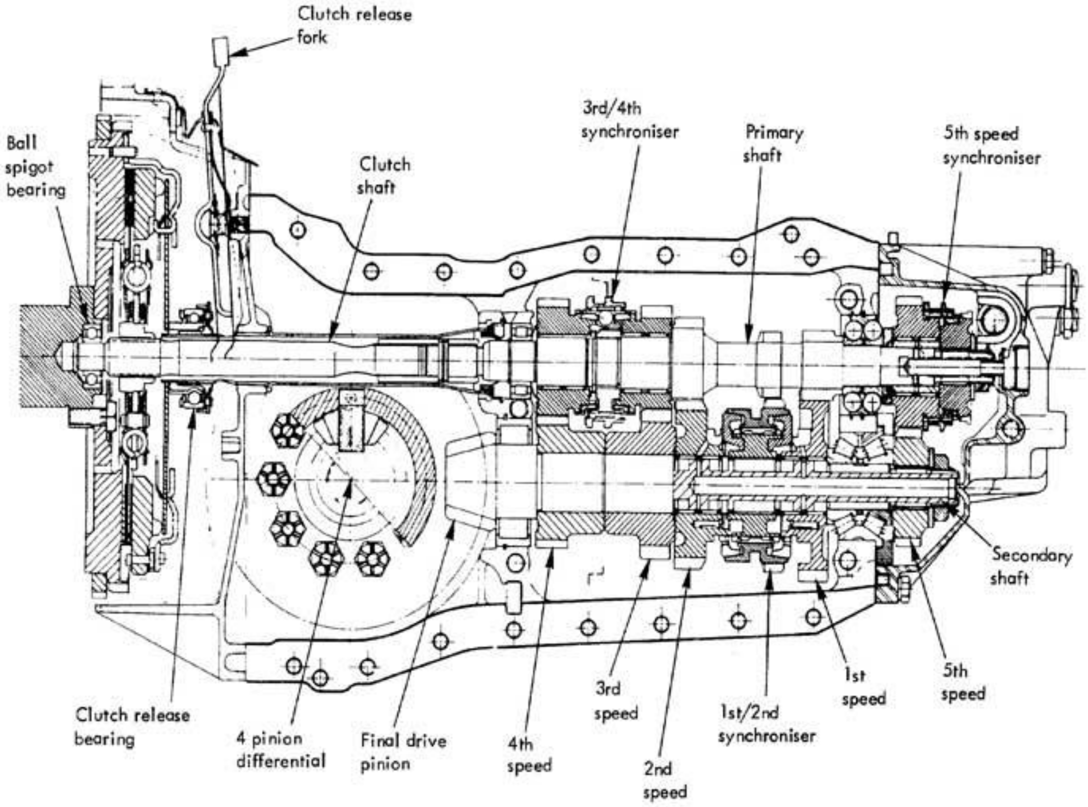


Fig. 5

1.2 Gear Ratio concept and analysis for compound gear

The manual transmission using the simple compound gears. The ratio for the overall gears is show at the equation 1.

Geometry relation $(n_3 / n_2) = (N_2/N_3) = (d_2/d_3)$ .... (1.0)

Kinematic relation $(\omega_2/\omega_1) = (n_2/n_3) = (\alpha_2/\alpha_1)$ ………………….. (1.1)

Where:

- n = RPM
- N = Number of teeth (other books the symbol is t)
- d = Pitch Diameter
- ω = angular velocity (rad/s)
- α = angular acceleration (rad/s^2)

Equation (1) applies to any gearset no matter whether the gear are spur, helical, bevel or worm. The absolute value sign are used to permit complete freedom in choosing positive and negative directions. In the case the spurs and parallel gears, the directions ordinarily correspond to the right hand rule and are positive for counter-clockwise rotation. (Shigley's : 2008).

Simple gear train show at **figure 6**, for the example the overall gear ratio is:

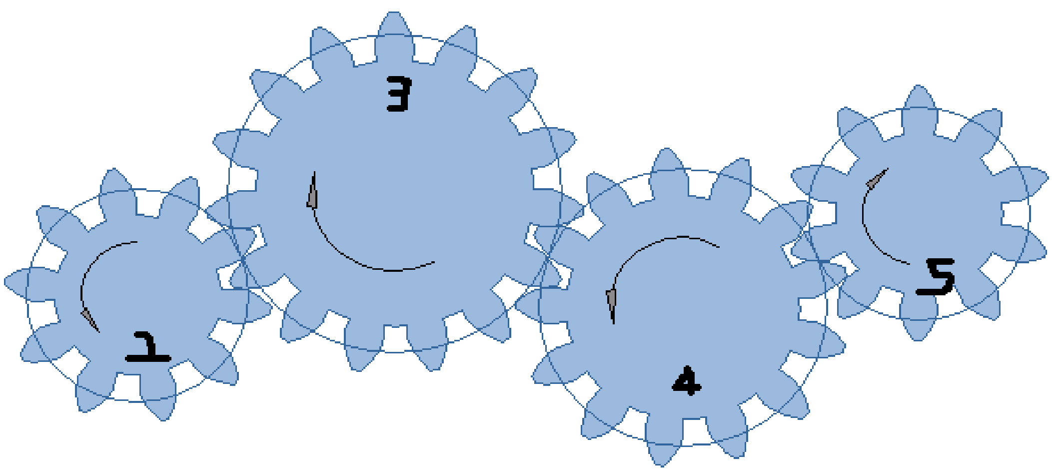


Fig. 6

$e_{overall} = e_{23} \times e_{34} \times e_{45} = (t_2/t_3) \times (t_3/t_4) \times (t_4/t_5) = (t_2/t_5)$

Figure 7 shows the example of the compound gear train with their teeth number and arrangement.

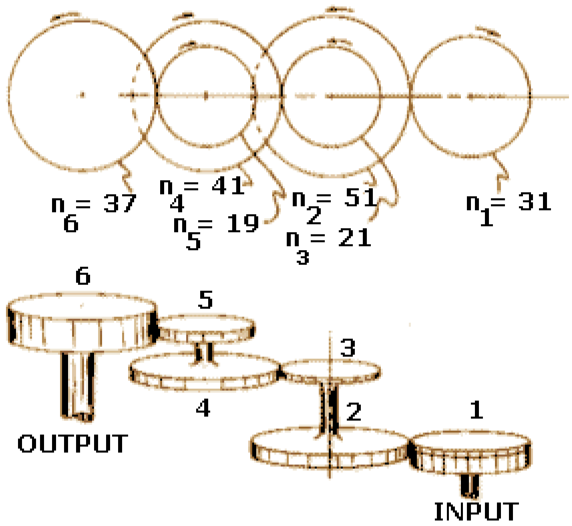


Fig. 7

The overall ratio η, of the compound gear are:

$e_{overall} = e_{12} \times e_{34} \times e_{56}$

$= (t_1/t_2) \times (t_3/t_4) \times (t_5/t_6)$ …………………………………….. (1.3)

Example

= (31/51) x (21/41)x (19/37)

= 0.1599

Efficiency of the gear train

$\eta = P_o/ P_i$ ………………………………………. …………… (1.4)

Power of the gear

$P = T\omega$ ………………………………………. …………… (1.5)

Conversion formula for rpm to Km/h

(n_3 /Differential ratio) = Axle rpm

Axle rpm X 60 = Axle rph

Axle rph X rolling diameter in KM = speed…………………… (1.6)

1.3 <u>Force acting on the spur gears.</u>

Figure 8 shows the free body diagram of the force and moment acting upon two gear of a simple gear train. (Shigley's : 2003)

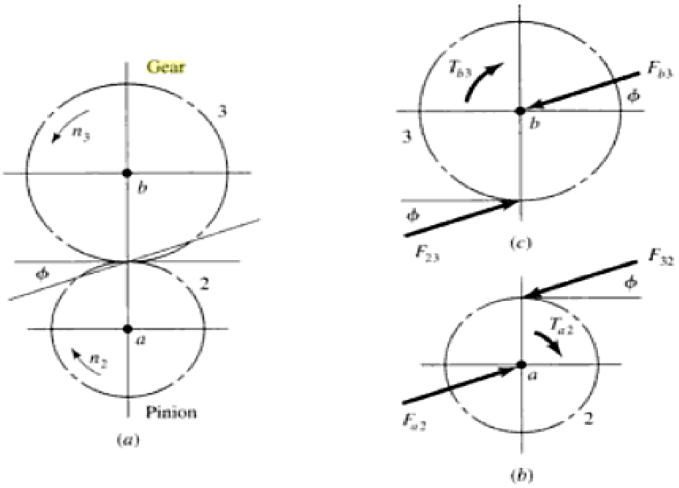
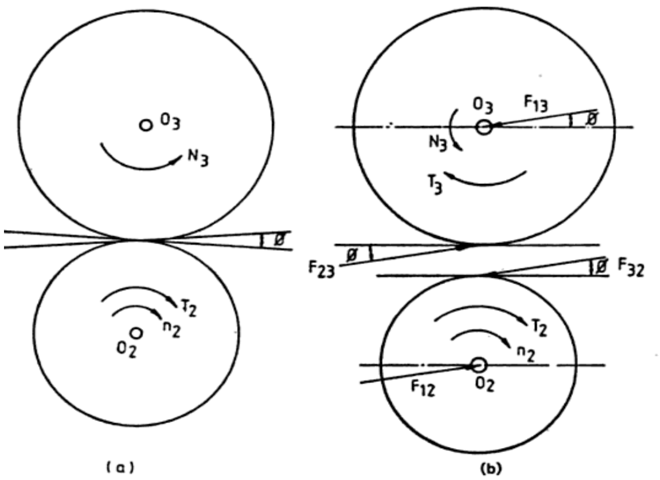


Fig. 8

Figure 9 shows the resolution of the gear force. (M. Klebanov: 2008)



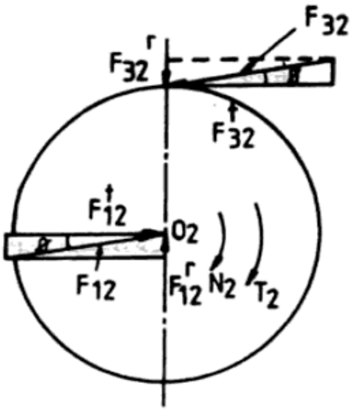


Fig. 9

Many gear design problems will specify the power and speed. So the equation to determine the W_t, with the pitch line velocity and appropriate conversion factors incorporated as equation 1.5.

$$W_t = (60000H)/ (2\pi\, dn) \qquad \text{.......... (1.7)}$$

1.4 Analysis of the force conversion through manual gear box.

1.4.1 Analysis of the power from the engine (specification from manufacturer)

Gear box selection is come from the Daihatsu Sirion (Perodua Myvi). The torque diagram of the car is shows on the **fig 10**.

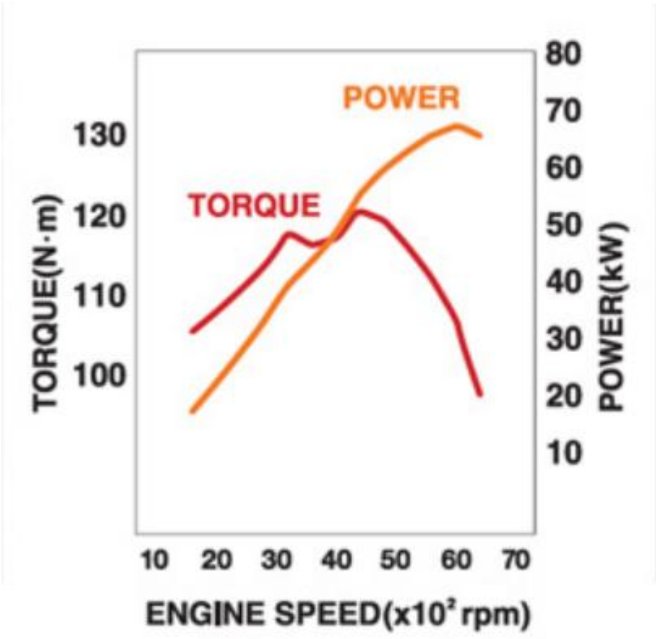


Fig. 10

The main specification for the power conversion through the gearbox is shown in **figure 11.** The engine displacement for the Myvi is 1298 cc.

Engine type		K3-VE, petrol, inline 4-cylinder, 16V DOHC with DVVT
Total displacement	cc	1,298
Bore X Stroke	mm	72 X 79.7
Compression ratio		10.
Max output	kW/rpm	67 / 6,000
Max torque	Nm/rpm	120 / 4,400
Transmission		Forward 5-speed, manual all synchromesh
Transmission gear ratio		1st: 3.182 2nd: 1.842 3rd :1.250 4th :0.865, 5th: 0.750 Rev: 3.143
Final reduction ratio		4.267

Fig.11 (Sin Tien Seng Pte Ltd)

From the **figure 10**, graph Torque vs Engine speed, when the engine speed runs at 3000 rpm the high torque produce by the engine. The torque produced is about 118 Nm. From the specification, the maximum torque is at 4400 rpm. At this speed the car have more power to move forward. The maximum power of the car is 67 KW at 6000 rpm.

The given gear ratio from the manufacturer is shown in figure 11. The first gear ratio is higher than second gear ratio. So the conclude of the gear ratio is reverse gear > gear 1 > gear 2 > gear 3 > gear 4 > gear 5. The reverse gear need the high gear ratio because of the torque. When car at initial speed, the drive shaft need a more power to move out the car, this scene is same to the first gear.

1.4.2 Gear ratio analysis

Gear ratio analysis was determined using the equation 1.0. Manufacturer is not given the value every teeth of the gear set, the manufacturer give only the overall car gear 1 ratio. The number of teeth is not given maybe the number of teeth is the one of the company secret (just make assumption). Otherwise how the manufacturer evaluated the value for the overall ratio of the first gear (**based on fig 3**) is:

$$e_{overall} = e_{23} \times e_{45}$$

$$e_{overall} = (N_2/N_3) \times (N_4/N_5)$$

$= 1.382: 1$ this value is given from the manufacturer

* Using the same solution to find the other gear set.

The finding for gear ratio analysis was the ratio calculation have found by calculate the meshing of the gears.

1.4.3 Optimum speed and maximum speed

Maximum speed and the optimum speed of the car based on the gear. The analysis for the gear 1, gear 2, gear 3 gear 4, gear 5 and reverse gear are:

1.5 Analysis example

Gear 1 Output speed

For the optimum speed

At the speed 4400 the torque is 120 Nm

$(n_3/n_2) = e_{23}$

$(n_2) = (n_3/ e_{23})$

$(n_2) = 4400/ 3.182$

$(n_2) = 1382.78$ rpm

Using the equation 1.5 to evaluated the speed of the car. Standard tyre radius from manufacturer is 15 inch. The conversion for 1 inch = 0.0254m.

(974.2 /4.267) = 228.31 rpm

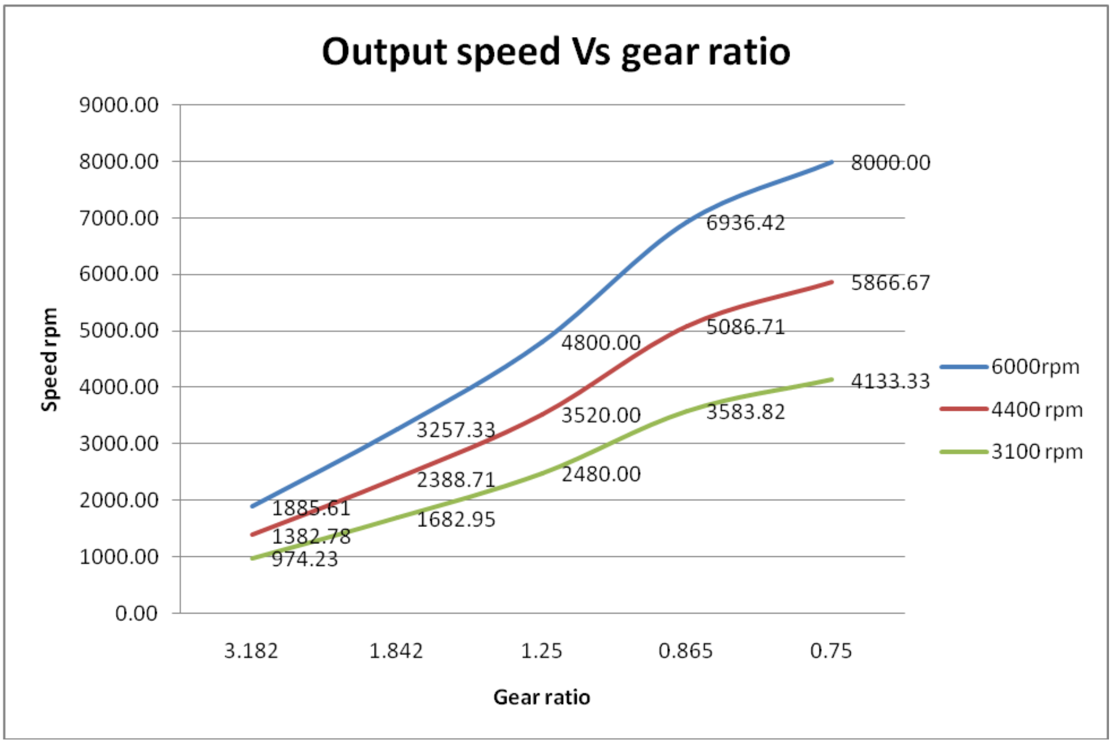
228.31rpm X 60 = 13699 rph

13699 rph X 1.904 $x10^{-3}$ KM = 26.1KM

1.5.1 Others result for output speed in rpm and Km/h shows in table 1.

	Engine	**Economy speed**	**car speed**	**optimum**	car speed	**max power**	car speed
	Ratio	**3100 rpm**	**kmh**	**4400 rpm**	kmh	**6000 rpm**	kmh
Gear 1	**3.182**	**974.23**	**26.08**	**1382.78**	37.02	**1885.61**	50.48
Gear 2	**1.842**	**1682.95**	**45.06**	**2388.71**	63.95	**3257.33**	87.21
Gear 3	**1.25**	**2480.00**	**66.40**	**3520.00**	94.24	**4800.00**	128.51
Gear 4	**0.865**	**3583.82**	**95.95**	**5086.71**	136.19	**6936.42**	185.71
Gear 5	**0.75**	**4133.33**	**110.66**	**5866.67**	157.07	**8000.00**	214.18
Reverse	**3.143**	**986.32**	**26.41**	**1399.94**	37.48	**1909.00**	51.11
differential	**4.267**						

Table 1



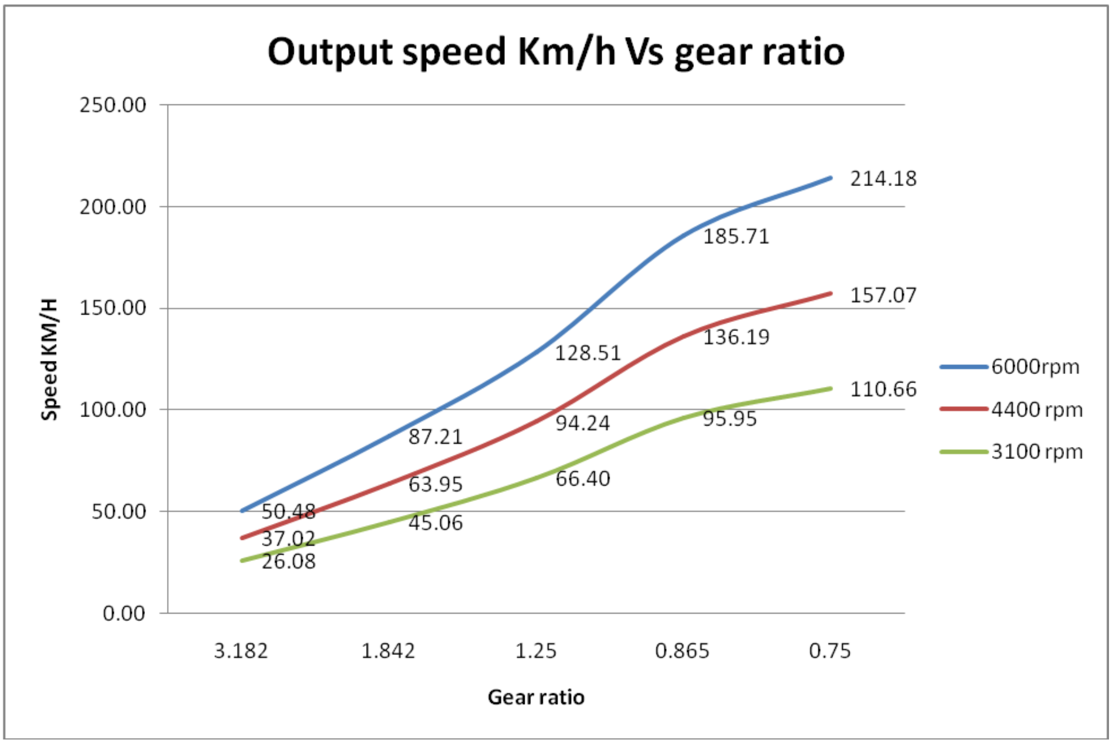
Graph 1.

Graph 1 shows the plotting output speed (RPM) vs Gear ratio at economy engine running (3100 rpm). The findings from the graph are, when the gear ratio in high value, the output speed of the system is about 974.23 rpm. The increasing value of the output speed when the value of the gear ratio decreases. The observation from the graph was the gear ratio at 1.842 equal 1682 rpm, 1.25 equal 2480 rpm, 0.865 equal 3583.82 and 0.75 equal to 4133.33 at output stage respectively.

The plotting graph output speed (RPM) vs Gear ratio at optimum engine running (4400 rpm). The findings from the graph are, when the gear ratio in high value, the output speed of the system is about 1382.78 rpm. The increasing value of the output speed when the value of the gear ratio decreases. The observation from the graph was the gear ratio at 1.842 equal 2388.71 rpm, 1.25 equal 3520 rpm, 0.865 equal 5086.71 and 0.75 equal to 5866.67 at output stage respectively.

The plotting graph output speed (RPM) vs Gear ratio at maximum power and engine running at 6000 rpm (blue line). The findings from the graph are, when the gear ratio in high value, the output speed of the system is about 1885.61 rpm. The increasing value of the output speed when the value of the gear ratio decreases. The observation from the graph was the gear ratio at 1.842 equal

3257.33 rpm, 1.25 equal 4800 rpm, 0.865 equal 6936.42 and 0.75 equal to 8000 rpm at output stage respectively.



Graph 2

From the **graph 2**, graph shows the trend speed in Km/h opposite the gear ratio. Green line trend shows the speed of the when engine running at 3100 rpm. At the first gear (3.182) the possible speed is about 26.08 Km/h. At the second gear (1.842) the speed of the car 45.06 Km/h. when the driver shift the gear knob to the third gear the possible speed is 66.40 Km/h. Forth gear (0.865) the possible speed at 3100 rpm is the 95.95 Km/h. At the fifth gear (0.75) the car will move at 110.66 Km/h.

Graph shows the trend speed in Km/h opposite the gear ratio. Red line trend shows the speed of the when engine running at max torque (4400rpm). At the first gear (3.182) the possible speed is about 37.02 Km/h. At the second gear (1.842) the speed of the car was 63.95 Km/h. When the driver shift the gear knob to the third gear the possible speed is 94.24 Km/h. At the Forth gear (0.865) the possible speed at 4400 rpm is the 136.19 Km/h. At the fifth gear (0.75) the car will move at 157.07 Km/h.

Graph shows the trend speed in Km/h opposite the gear ratio. Blue line trend shows the speed of the when engine running at max power (6000rpm). At the first gear (3.182) the possible speed is about 50.48 Km/h. At the second gear (1.842) the speed of the car was 87.21 Km/h. When the driver shift the gear knob to the third gear the possible speed is 128.51Km/h. At the Forth gear (0.865) the possible speed at 6000 rpm is the 185.71 Km/h. At the fifth gear (0.75) the car will move at 214.18 Km/h, the possible top speed of the car.

The trend line concludes if we want to drive at fuel economy, the suitable speed is at fifth gear at 3100 rpm, refers to the **fig 10** at the speed the engine has already give the high torque. For climbing the hill the most suitable speed at 4400 rpm and fourth gear because the car has a power to climb the hill. For the example we take the hill surroundings Malaysia the highest hill climbing is Genting Higland, when climbing this hills using Perodua Myvi, the possible best gear selection is at third gear at 4400 rpm because at the engine speed the maximum torque was produce by the engine bay.

CONCLUSION

Gears are used to transfer motion from one object to another in a mechanism. There are many important design considerations with respect to gears. The most fundamental calculation for gears is the gear ratio. This ratio describes the relative motion of the gears involved. A high gear ratio corresponds to a high torque output and a low gear velocity. The gear ratio can be used to determine the proper number of teeth for the gears. The output speed of the vehicle is depends on the overall gear ratio.

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