Recent Decisions in Technologies for Sustainable Development

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Geometric Progression Application In Design Transmission Gear Ratio

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Abstract. One of the important aspects in determining the competitiveness of an automotive product is the traction ability or performance, the vehicle's ability to accelerate, wind resistance, rolling resistance, against the force of the ramp, and the capacity to pull a load. The size of traction for any level of gear and vehicle speed that can be achieved can be controlled by adjusting the ratio and transmission rate. Transmission ratio affects the amount of torque that can be transmitted, while the number of speed levels affects the fineness of the process of transmission and transformation of power in the transmission system. To find a gear ratio between the lowest and highest transmission rate is by geometric progression. The basis of the use of this method is to get the ratio and amount of gear transmission rate of speed at the same engine operating speed so that fuel economy will be the same on each transmission. Modified gear ratio produce traction curve where the distance curve closer adjacent transmission. This indicates a loss of power transmission shifting is getting smaller or in other words the better traction performance. The design of the installation ratio 6-speed, generating traction curve with the distance between the curve near the sting traction, produces good traction or good performance.

Introduction

Traction performance is one important aspect in determining the competitiveness of automotive products. Traction performance of an automotive product has been counted on paper at its design stage. However, because the design process is an iterative process that will require the calculation of performance over and over again to produce a quality automotive product. One of the important performances is the vehicle's ability to accelerate, wind resistance, rolling resistance, against the force of the ramp, and the capability to pull a load. The force arises on the drive wheel to counter these obstacles called thrust or traction force. Traction force that occurs in the contact area of the drive wheel and the road is affected by many factors such as: the engine torque characteristics, characteristics of the coupling, ratio and rate of transmission, axle ratio, characteristics of the propeller shaft, effective diameter of the wheel, and the wheel and the road contact characteristics. Of the many parameters that affect one of the most influential is the ratio and transmission rate. The size of traction for any level of gear and vehicle speed that can be achieved can be controlled by adjusting the ratio and transmission rate. Transmission ratio affects the amount of torque that can be transmitted, while the number of speed levels affects the smoothness of the transmission and transformation of power in the transmission system. Thus the vehicle's ability to accelerate, climb through, against the force of the wind, as well as the rolling resistance can be controlled through proper design of the transmission ratio and the number of levels.

Sutantra et al. describe the characteristics of the drive line and its effect on vehicle traction behavior [1]. Wirakusuma tests and analyzes Toyota vehicle traction characteristics [2]. Hartana discusses wind load characteristics and look for aerodynamic coefficients of several types of vehicles, then analyzes the effect of wind loads on the directional stability and traction capabilities of the vehicle, generates in these studies that the drag, lift and pitching moment that looks influence on vehicle traction capabilities [3]. Adi Atmika reviews comparison traction characteristics and

transmission performance on standard systems and system modifications [4]. Agus Sigit et al. lay on gearless traction performance transmission [5]

Method

Formula Traction and Resistance

Traction characteristics on motor vehicles principally cover the vehicle's ability to accelerate, and overcome the obstacles that occur, including rolling resistance (rolling resistance), climb obstacles, as well as aerodynamic resistance [6].

$$F = R_a + R_r + R_d + R_g + \frac{W}{g}.a \quad (1)$$

where :

F = total traction force required
Ra = aerodynamic resistance
Rr = Rolling resistance
Rd = resistance for pulling loads
Rg = climb obstacles.
W = total weight of the vehicle
a = acceleration of vehicle

To remove power (power) from the engine to the drive wheel rotation required a certain mechanism. The mechanism used to transfer power from the motor to the drive wheel is called the Power Transmission System or System Drive Train.

In general, a series of mechanisms that are used to transfer power from the motor to the drive wheel, consists of clutch, gear box, propeller shaft and differential

In the drive train system will produce losses or losses caused by the friction between the teeth on gears, friction in the bearings, and the resistance of lubricating oil. The following is the usual price efficiency for multiple drive train system components [6].

- Clutch: 99%
- Each pair of gears: 95-97%
- Bearing and connections: 98-99%

When a drive train system is characterized by the parameters of the drive train system efficiency (η_t) and reduction gear ratio (i), the traction on the drive wheels can be formulated [6]:

$$F_k = \frac{716.P.i_k.i_d}{N.r}\eta_t \quad (2)$$

where:

Fk = traction force on the level of k (kgf)
P = engine power (Hp)
N = engine speed(rpm)
r = radius of the drive wheel (m)
ik, id = ratio of the k-th gear and gear ratio differensal.

Or equation 2 is written in another form [6]:

$$F_k = \frac{M_e(v).i_k.i_d}{r}\eta_t \quad (3)$$

where:

Fk = traction force on the level of k (N)
Me = engine torque to velocity v (Nm)

Then the relationship between vehicle speed and engine rotation speed is [6]:

$$V = \frac{0{,}06(1-s).\pi.D.N}{i_d \times i_k} \quad (4)$$

where:

V = vehicle speed (km / h)
s = coefficient of slip on the tires (2-5%)
D = diameter of the wheel (m)
N =engine speed(rpm)

In preliminary calculations, gear ratio between the highest and lowest can be found using the law Progression Geometry. The basis of this method is the speed limit of engine operation lowest (ne1) and highest (NE2) should be determined in advance. This determination is based on the torque characteristics of the engine, usually selected around the maximum torque of the engine.
The concept of a geometric progression method can be seen in Figure 1 [6].

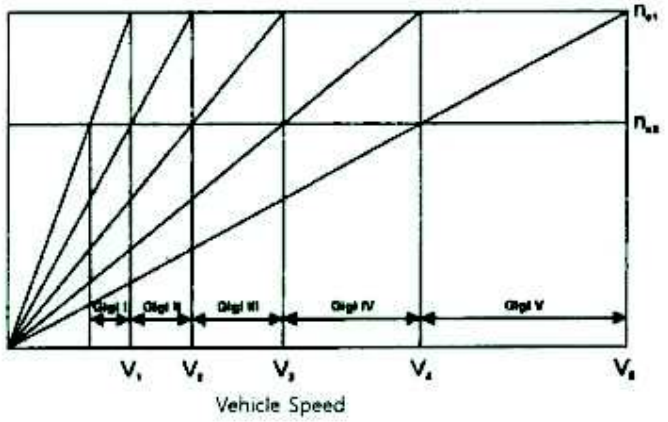

Figure 1.Gear Ratio Selection with Geometric Progression [5]

Research procedures

The initial step of the research is to obtain the characteristics of the power-torque engine model vehicles. The characteristics of this model are obtained with the engine in the chassis dynamometer testing. Based on the characteristics of the power-torque engine performed the initial analysis using the standard transmission system to the needs of traction on the vehicle when crossing the road conditions vary and different load conditions. Then do the analysis of the traction capabilities are able to produce a standard transmission system. Having obtained the traction characteristics by using standard transmission then made modifications to the transmission system using geometric progression.

Modifications to the method of progression-free geometry modification system, which is the gear ratio of the initial and final gear ratio designed himself. The ratio of the gear (low) is determined by the maximum speed of the vehicle to be designed, whereas the maximum traction gear ratios determine the initial (highest). Then the ratio of the boundary between the two is made in such a way that the resulting traction vehicles can approach the ideal characteristics. Transmission systems that have been modified subsequently used to obtain a new traction performance.
It is expected to make modifications to the transmission system obtained better traction performance than a standard transmission. The analyses were performed with the help of excel software. From the graph of performance traction with a standard transmission and a modified transmission performed a comparative analysis of the performance of the resulting traction.

Result and Discussion

Power-Torque Characteristics Model Engine Vehicle

For use in motor vehicles, power to the ideal characteristics of the source driving force is constant power generated at all levels of speed. With the availability of constant power, at low speeds will be available torque is large enough, will be used to generate sufficient traction on the tires to

accelerate the vehicle. With increasing speed, engine torque will decrease hyperbolic. This is in accordance with the needs of traction on the vehicle, where the speed is high enough, no longer needs huge traction.

Vehicle is taken as the object to be designed and traction characteristics and a number of modifications Ratio transmission systems have the following specifications;

- The empty vehicle weight (W_k) : 1150 Kg
- Wheel Base (L) : 2390 mm
- Distance from axcel to CG (L1) : 1147 mm
- High of CG (h) : 450 mm
- Maximum torque : 143 Nm / 4000 Rpm
- Transmission : 5 speed level
- Standard of Ratio System : I; 3,545 II;1,904 III; 1,310 IV;0,969 V; 0,769
- Differiantial Ratio : 4,105
- Wheel Diameter : 0,30 m

Then in particular for vehicle models, charts rounds vs. engine power, is shown in figure 2.

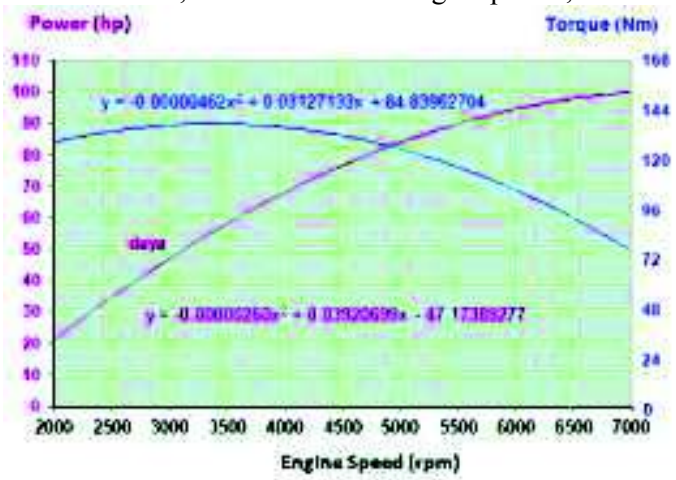

Figure 2 Power-Torque Characteristics of vehicle models

Traction Characteristics

The ratio of the gear (low) is determined by the maximum speed of the vehicle to be designed, whereas the maximum traction gear ratios determine the initial (highest). Then the ratio of the boundary between the two is made in such a way that the resulting traction vehicles can approach the ideal characteristics. The result of the design of gear ratios for mounting 4, 5, and 6 speed levels are shown in Table 1.

Table 1.Ratio Gear Design Results

Ratio	4 level	5 level	6 level
I	3.322	3.322	3.322
II	2.134	2.383	2.547
III	1.371	1.710	1.953
IV	0.883	1.227	1.497
V		0.883	1.148
VI			0.883

Traction calculation results are displayed in graphical form characteristic traction standard conditions in Figure 3, and the results of the modification at each speed level are shown in figure 4, figure 5, and Figure 6.

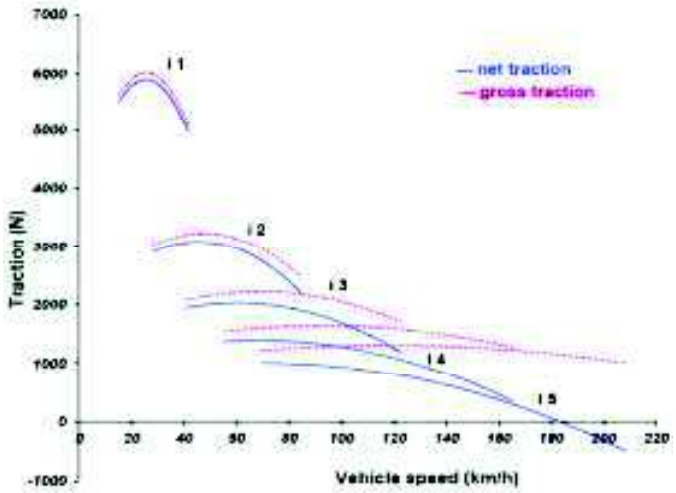

Figure3. Characteristics of the performance of the transmission gear ratio standard

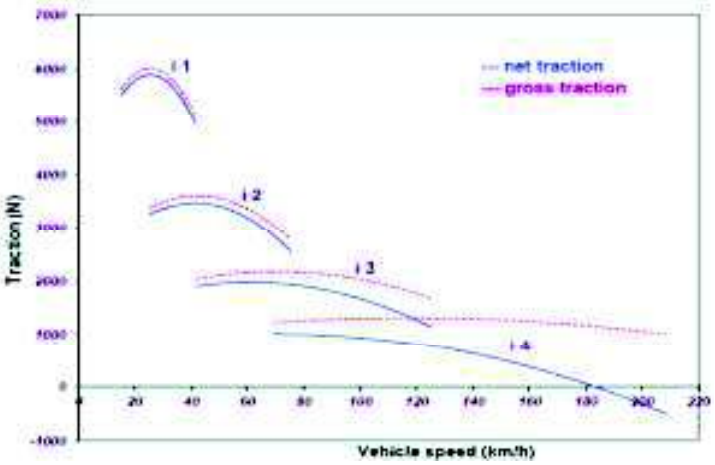

Figure 4. Characteristics of the transmission performance at 4 levels of speed

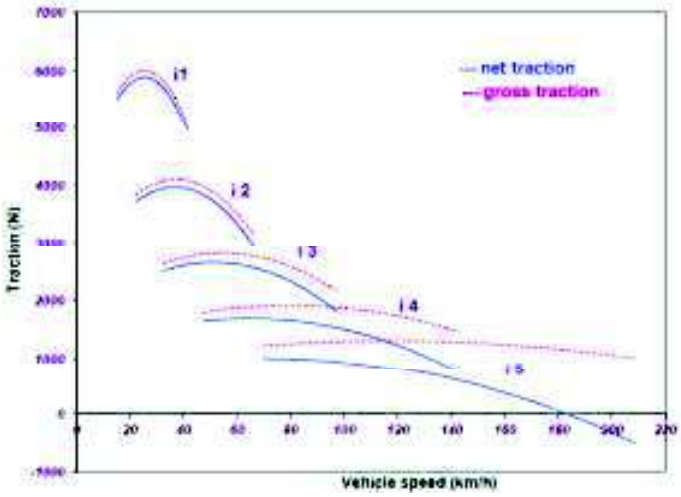

Figure 5. Characteristics of the transmission performance at 5 levels of speed

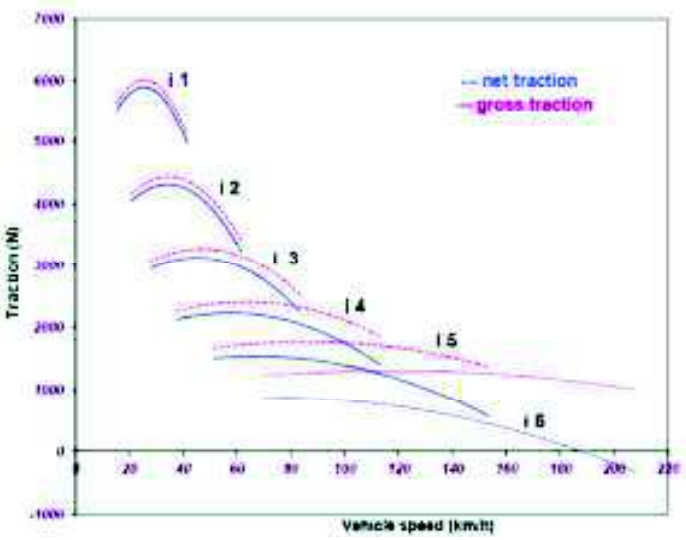

Figure 6. Characteristics of the transmission performance at 6 levels of speed

Discussion

From the graph modified, the distance between adjacent tooth curves is getting closer. This indicates a loss of power transmission shifting is getting smaller or in other words the better traction performance. Then from Figure 6, the ratio of the design and the installation of 6-speed, the distance between the curve near the sting traction, produces good traction or good performance.

Conclusion

From the calculation and the result of the analysis some conclusions can be drawn as follows:

- By changing the gear ratio of the transmission of the vehicle, the traction force generated will vary and affect the ability of the vehicle through the specific operating conditions.
- The distance between the two curves traction gear ratio indicates the amount of unused traction. The graph shows that the performance of the transmission of many transmission rate, the less traction is wasted.
- The design or modification ratio with 6-speed traction produces the best performance.

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