International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

A Study on Load Transfer during Different Forward Dynamic Conditions of a Two-Axle Vehicle

Sree Harsha Bharadwaj H[1]

B.E, M.Tech (Student)

Abstract: ***Few basics of the vehicle dynamics of a bi axle vehicle using an appropriate example as a case study is reported in order to realize the effect of the same. The major forces which causes the vehicle to move forward occurs at the contact point of the tire and the road. The effect of load transfer during acceleration and de acceleration on a flat surface, lateral acceleration, and effect of load transfer due to banking of road, vehicle parked and accelerating in an uphill condition is realized by solving analytically and by plotting the graphs using a simple example. The same can be applied to any other bi-axle vehicle and effect can be realized.***

Keywords: GVW, Static, Dynamic, Uphill, Downhill, Banking

Introduction

In day to day life, vehicles are based on different principles and travel by different modes and speed. While considering on the on road mode and particularly the on highway, the friction force is the only thing which keeps the vehicle in motion. Also, De Alembert"s principle has to be considered while analyzing a body in a motion due to some external force. "Alembert"s principle, alternative form of Newton"s second law of motion, stated by the 18th-century French polymath Jean le Rond d"Alembert. In effect, the principle reduces a problem in dynamics to a problem in statics. The second law states that the force F acting on a body is equal to the product of the mass m and acceleration a of the body, or F = ma; in d"Alembert"s form, the force F plus the negative of the mass m times acceleration a of the body is equal to zero: F - ma = 0. In other words, the body is in equilibrium under the action of the real force F and the fictitious force -ma. The fictitious force is also called an inertial force and a reversed effective force. While D'Alembert's principle is merely another way of writing Newton's second law, it has the advantage of changing a problem in kinetics into a problem in statics. The techniques used in solving statics problems may then provide relatively simple solutions to some problems in dynamics; D'Alembert's principle is especially useful in problems involving constraints.

Methodology

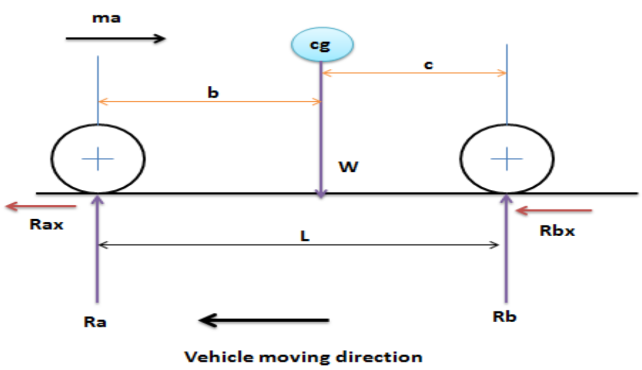

Figure 1: Vehicle in Forward Motion

Case 1: when vehicle is in static condition or at rest

For a body to be in equilibrium there are criteria to be satisfied

$\sum F_y = 0$

$\sum F_y = 0$

$\sum M = 0$

Taking moment about point A,

Rb = (W.b) / L

Ra = (W.c) / L

Case 2: when a body is accelerating on a flat road

$\sum Fx = ma$

$\sum Fy = 0$

$\sum M = 0$

Ra + Rb= w

Rax + Rbx = ma …………… (1)

Taking moment about CG

Ra (b)-Rb (c) + (Rax Rbx).h=0

Substituting by eqn (1)

W.a.h + Ra.b = Rb.c

Upon solving

Rb = (W.b)/L + (W.a.h)/L

And Ra = (W.b)/L - (W.a.h)/L

Case 3: weight transfer due to lateral acceleration

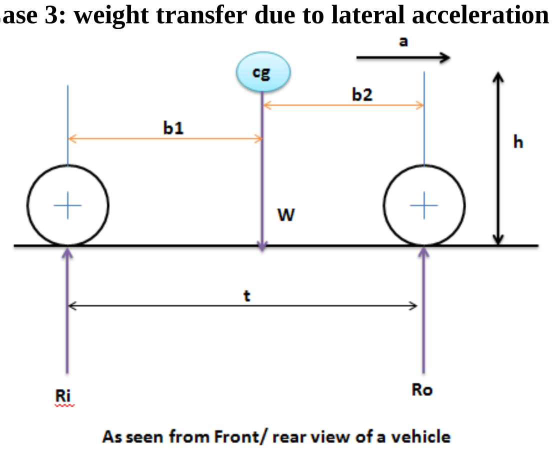

Figure 2: Front View of a Vehicle and Its Specifications

Considering the track width as „t" as seen from the front view of a vehicle,

Ro as outer tire reaction force and Ri as inner tire reaction force, we arrive at

Ro.t = (W.a.h)/g + W. (t-d)

Ro = (W.a.h)/t.g + W. (t-d)/t
Similarly
Ri = W. (d)/t + (W.a.h)/t.g

Case 4: Banking of road
In case of banking, the final equations obtained are
Ri = (1/t)*((W.b.cosØ) - (W.h.sinØ))
Ro = (1/t)*((W.b.cosØ) + (W.h.sinØ))

Case 5: vehicle parked on uphill

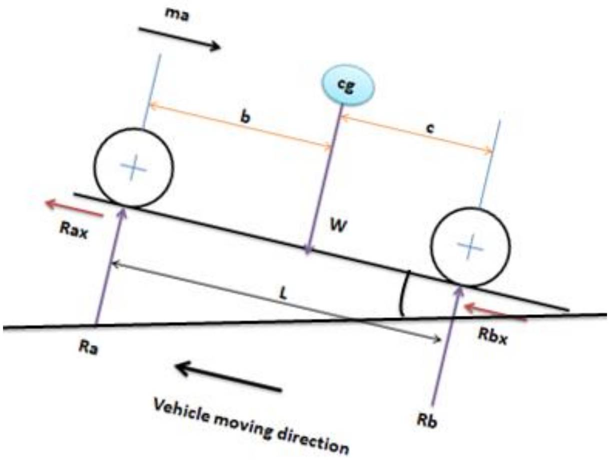

Figure 3: Vehicle Parked on Uphill

Ra = W.b.cosØ/L + (W.h.sinØ)/L
Rb = W.b.cosØ/L - (W.h.sinØ)/L

Theoretical Case Study

The inputs of the vehicle are shown below and the same methodology has been adopted to solve and plot the graphs and to realize the effect of load transfer.

Table 1: Dimensions of vehicle

GVW	1500	kg
B	1136	mm
C	1136	mm
L	2272	mm
a_x/g	0	*
H	600	mm
ɵ	30	deg
d(distance from outer tire to CG during cornering)	750	mm
t(track width)	1500	mm
µ	0.8	*

Results and Discussion

Case 1
The above analytical method is employed to determine the loads i.e. FAW and RAW.

During Static Condition

Ra in kg	750.0
Rb in kg	750.0

In fact, under the static condition, Rb>Ra in real practices. Here Ra=Rb since a=b in fig 1. This has been done so as to understand the concept easily.

Case 2
The result of case 2 as mentioned above in methodology section for the respective example is shown below in graph.

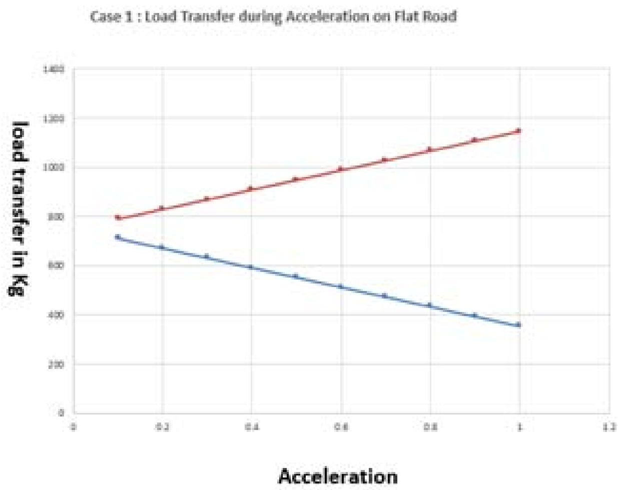

Figure 4: load transfer to the rear axle during acceleration of the vehicle

It is evident from fig 4 that the load transfers to rear axle as the vehicle acceleration increases. Also, the nature of graph remains same for the entire bi axle vehicle and the nature of graph for de accelerating also follows the same.

Case 3

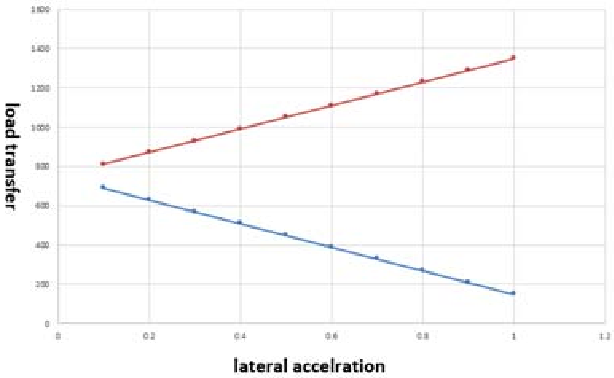

Figure 5: Graph for Lateral Acceleration

It can also be seen that the nature of graph for lateral load transfer is same as the previous one. When the lateral acceleration increases, the lateral load shift increases and at certain point the roll over takes place.

Case 4

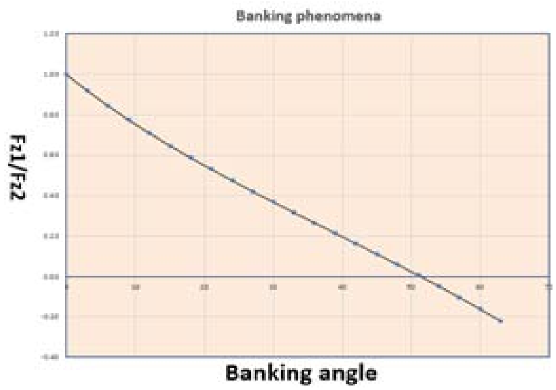

Figure 6: Graph of Banking

From the above fig 6 it is evident that the vehicle can be safe until the valve of tan Ø is less than b2/h and if it exceeds b2/h, then roll over will take place and is unsafe to the vehicle. Figure 6 illustrates the behavior of force ratio Fz1 /Fz2 as a function of φ for h = 0.6m and w = 1.52m. The rolling down angle φM = tan−1 (b2/h) = 51.71 deg indicates the bank angle at which the force under the uphill wheels become zero and the car rolls down. The negative part of the curve indicates the required force to keep the car on the road, which is not applicable in real situations.

Case 5:

During uphill (parked)	
Ra in kg	451.46
Rb in kg	948.06

It is evident from the above result that the valve of Rb is greater than Ra when a vehicle is parked in uphill condition.

References

[1] Thomas D Gillespie, “fundamentals of vehicle dynamics”.
[2] Jazar, R.N., “vehicle dynamics: theory and application, 2008, XX, 1015 p.585 illus.

Author Profile

Sree Harsha Bharadwaj Hotur received the B.E. degree in Mechanical Engineering from BIET Davangere under Visvesvaraya technological university in the year of 2014 and presently pursuing Mtech in NIE, Mysore and also has a couple of publications in International journal, focusing on Entrepreneurship.