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Research Article

# Modeling between Torque and Curvature Angles and Time etc. Parameters in the Slope of Heavy Vehicle

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## Abstract

As the curvature angle enhances the torque will vary from stability scope to peak then to stability in slope curve of vehicle. When the power enhances the torque may enhance correspondingly meanwhile as the rotational speed decreases it may enhance as well. The maximum torque has afforded 500kNm in the curve for the conditions of 320r/m and 523kW meanwhile the second maximum one has afforded 280kNm in the same for the conditions of 220r/m and 208kW in vehicle with heavy loads. In the end the maximum stability one will maintain in 10kNm with the 320r/m and 523kW in curve of vehicle dynamics. The stabilized torque will reduce about 3kNm to compare with the adjacent two conditions. The torque may indicate 4kmNm, 3mNm and 2mNm for the time of 0.2s, 0.4s and 0.6s in slope curvature correspondingly. It expresses that the bigger power may afford bigger torque and then rotational speed in this paper.

**Keywords:** Modeling; Torque; Curvature Angles; Slope; Heavy Vehicle; Dynamics; Parameters; Rotational Speed; Power; Radius of Curvature; Radius of Tire

## Introduction

The heavy vehicle may have been dominated with artificial intelligent driving and intelligent spaces largely. Many creative investment to heavy vehicle presents that in near two years intelligent vehicles that have been focus on by industries and investments may have more wide development space further [1]. The power transmission of an heavy vehicle is driven by power on the slope curve, which is generated by the engine. Therefore, the measurement of torque is the evaluation of the heavy vehicle engine system on the slope curve, has an important role. This paper studies the overall performance of the heavy vehicle, including whether the slope curving performance of the heavy vehicle achieves the best performance, through the torque and rotation of the heavy vehicle engine.

The kinematics of the heavy vehicle takes speed and torque etc. research parameters as the main purpose of design. [1-18] Therefore, the organic combination of torque and movement is the real purpose of evaluating the heavy vehicle. The heavy equipment transporter also has power to be 435hp whilst 4.8 tons heavy truck may have more than 520hp power according to the relative narration in internet. With the increase of horsepower, their dynamic analysis and kinematics for curve and slope curve become particularly important. Such as torque and rotational speed analysis. The torque of a heavy vehicle is the most important factor. It involves in the main condition that designers should expect in advance that they can finish the task without failure. The heavy vehicle's power and torque etc. less trouble is the embodiment of its design level capability. The torque of the heavy vehicle is the main performance of the torque while the torque is directly reflected in its engine function. A good engine function will be achieved in a relatively short angle in a curve. Therefore, this paper explores whether the data of heavy vehicle design are feasible based on the high power and torque of the heavy vehicle and discusses the status of high power and high torque to meet the needs of future heavy vehicle development on a slope curvature. To enhance energy efficiency, construct renewable energy, improve power grid modern work and enhance the rechargeable battery technology of hybrid vehicle with plug-in electricity they have been dominated by us [3]. Up to 2030 the plug-in chargeable station and hydrogen energy fuel vehicle will have attained dominant position. As predicted in 2040 the 75% vehicle will have been occupied by electric vehicle [4].

## Calculation Results

The torque and force may be known in curve of tire on the slope. The vehicle tire may rotate toward curve in terms of the schematic principle. Here θ is the curvature angle; $\theta_1$ is the slope angle; F is the tire force; s is displacement; R is the radius of curvature. Their formulae will be deduced according to the principle above and they may be known as follows.

According to energy reservation law for curve of vehicle tire it has

$$w = Fcos\frac{\theta}{2} \cdot s \quad (1)$$

*So it has*

$$dw = \int_{s_1}^{s_2} 2Fs \cdot d(cos\frac{\theta}{2}) \quad (2)$$

So it has $M = \frac{30PR}{\pi nrcos\frac{\theta}{2}}$ (3)

*Meantime, from (1) it has*

$$dw = Fcos\frac{\theta}{2} \cdot ds \quad (4)$$

It may be deduced as

$$It\ has\ P = \frac{Fs}{t} cos(\frac{\pi nt}{60}) \quad (5)$$

Supposed that M is curvature torque, Nm; n is rotational speed, r/m; $n_1$ is the curvature angle; t is the angle, s; r is tire radius, m.

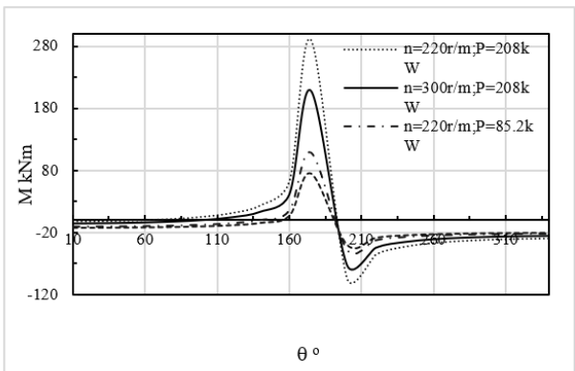
Here, $n_1 = r/R \cdot n$.

Since in slope it has $F = \frac{2M}{3r} + \frac{m}{3} sin\theta_1$ (6)

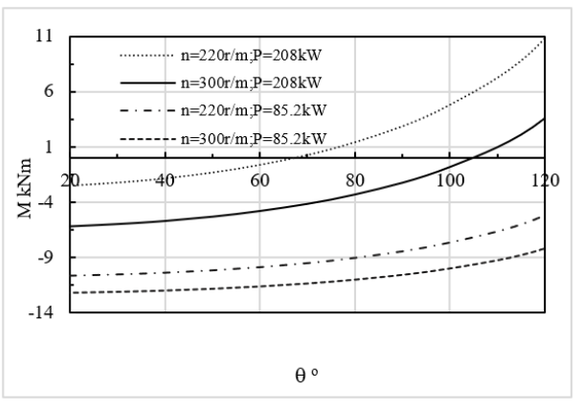
$$It\ has\ M = \frac{45P}{\pi ncos\frac{\theta}{2}} - \frac{mrsin\theta_1}{2} \quad (7)$$

## Discussions

According to the above formulae the torque will have been solved in here whose conditions may be clarified as rotational speed from 220r/m to 450r/m and power from 85.2kW to 523kW with curvature angles from 10º to 350º. At the same time, it is supposed that the vehicle gravity may become 2.9-3.9tons, the slope becomes 11-22º, the vehicle tire has provided 0.3m and radius of curvature has afforded 4m in this paper. They may be discussed as below in details.




(a)

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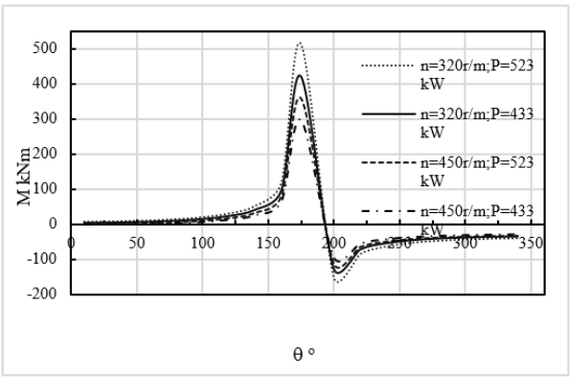


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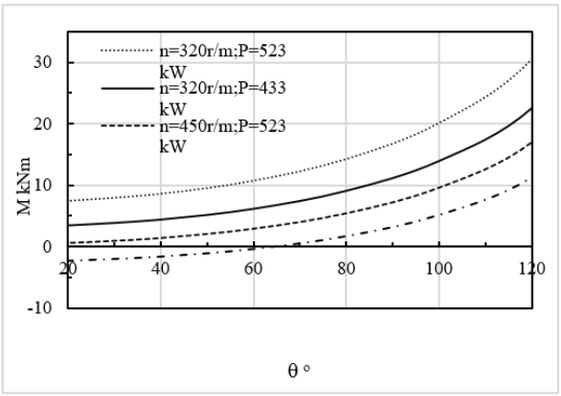


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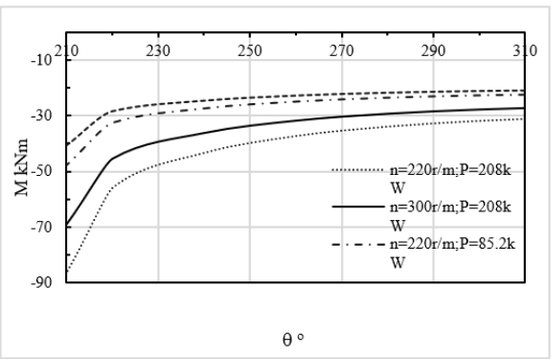
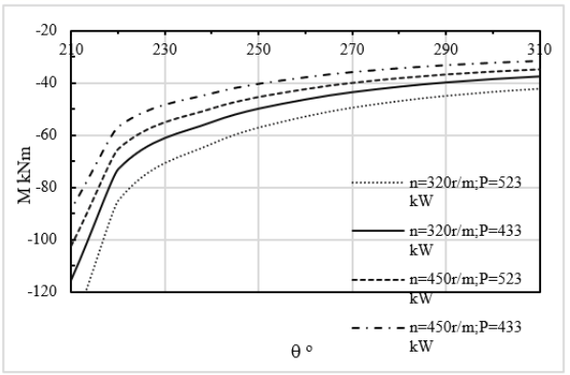



(e)




(f)

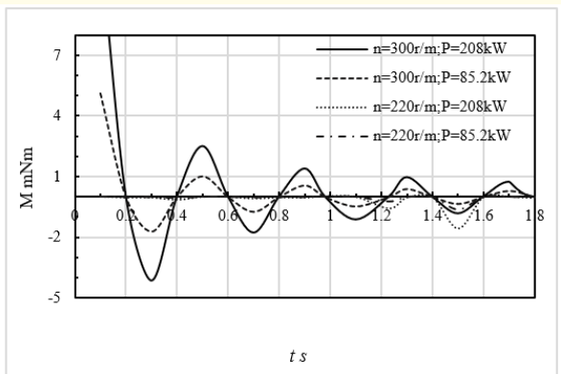
**Figure 1:** The graph of torque and curvature angle with various rotational speed and power for curve in vehicles.

From Figure 1 (a-d) it may be shown that the torque will increase into the first main peak firstly and then maintain a constant at last enhance to second minus peak finally with enhancing the curvature angle from 10º to 350º for gravity 2.9 tons, slope 22º, tire radius 0.3m and radius of curvature 4m in curve of heavy vehicle. The torque may increase from-2kNm to 280kNm firstly at the rotational speed to be 220r/m and power to be 208kW. The former may indicate stability one. As the rotational speed enhances to 300r/m it may decrease to 200kNm whilst the power reduces to 85.2kW it may decrease to 80kNm at the stable periodicity within curvature angle to be 50º-300º. That expresses that enhancing the rotational speed and reducing power may have reduced the torque. Eventually it will be enhanced again when the angle becomes from 200º to 350º. The torque variation may arrive in 0.2-0.5kNm with adjacent rotational speeds and powers in light of Figure 1(a).

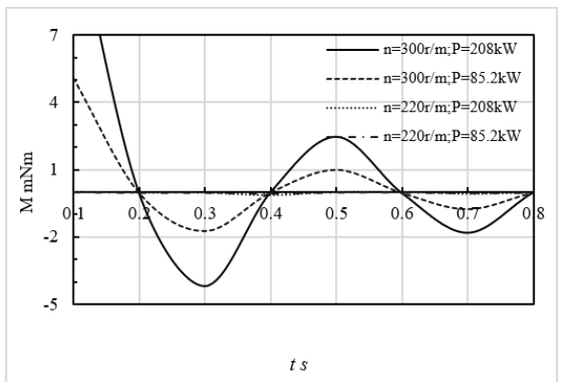
From Figure 1(b) it may exhibit that the torque will increase with enhancing the curvature angle from 20º to 100º. The torque may decrease from 280kNm to 100kNm at the rotational speed to be 220r/m and power to be 208kW with the curvature angle to be from 175º to 200º respectively. As the rotational speed enhances to 300r/m it may decrease about -2kNm whilst the power reduces to 85.2kW it may decrease about -10kNm. That expresses that enhancing the rotational speed and reducing power may have reduced the torque. The periodical stability has been -2kNm, -7kNm, -10kNm and -12kNm in turns according to Figure 1(b). That means the stability force may become 50kg~ 300kg as per one tire in turns in a curvature road for heavy vehicle.

From Figure 1(c) it may exhibit that the torque will become the similar status to discussing above. From Figure 1(d) it may exhibit that the torque will indicate the increased firstly and then decreased with enhancing the curvature angle from 20º to 350º. The torque may decrease from 500kNm to 300kNm at the different rotational speed and power as the figure shows. As the rotational speed enhances to 450r/m and the power reduces to 433kW the stability torque may decrease about -100kNm with the periodical frequency of one circle of curvature. That expresses that enhancing the rotational speed and reducing power may have reduced the torque.

Figure 1(e) may exhibit that the curvature angle change with scope of 40-80kNm and 22-30kNm at the angle of 210º and 310º correspondingly. Meanwhile, it may change with 80-120kNm and 32-42kNm at the same angle respectively in Figure 1(g). From the data it has been considered that the power affects torque firstly and then rotational speed according to the analysis in this paper.




(a)




(b)

**Figure 2:** The torque and time with various rotational speed to be 150r/m~300r/m and power to be 85.2kW~523kW for vehicle gravity to be 3.9 tons and slope to be 11º in heavy vehicles.

In Figure 2 (a and b) the torque may vary with varying the rotational speed and power for tire radius to be 30cm and radius of curvature to be 4m in heavy vehicles. The torque size may indicate 4mNm, 2mNm and 0.5mNm for the time to be 0.3s, 0.5s and 0.7s with the conditions to be 300r/m and 208kW in Figure 2 (b) respectively. Meantime it may indicate 60kNm, 30kNm and 20kNm for the time of 0.2s, 0.5s and 0.7s with the conditions of 300r/m and 85.2kW in Figure 2 (a and b) correspondingly. It expresses that

the bigger power may afford bigger torque here. The stability value will provide about zero, so that we take a look for maximum ones to estimate. The curve value with 300r/m and 208kW, 300r/m and 85.2kW, 220r/m and 208kW and 220r/m and 85.2kW may has various interval time about periodical frequency to be 0.4s in turns which indicates the tire frequency has been same.

At the same time it is supposed that the vehicle gravity may become 2.9~3.9tons, the slope becomes 11~22º, the vehicle tire has provided tire radius to be 0.3m and radius of curvature of 4m afforded in this paper. As the curvature angle may become enhancement one the torque will have stability scope in curve of vehicle as angle may be enhanced it will have decreased to stability shortly at the same curve. As the power enhances it may become enhanced correspondingly meanwhile as the rotational speed decreases it may enhance as well. The maximum torque has afford 500kNm in the curve of 320r/m and 523kW meanwhile the second maximum one has afford 280kNm in the same to 220r/m and 208kW. In the slope curve the maximum stability one will reach in -150kNm with the 320r/m and 523kW in curve road of vehicle dynamics.

## Conclusions

As the curvature angle enhances the torque will vary from stability scope to peak then to stability in slope curve of vehicle. When the power enhances the torque may enhance correspondingly meanwhile as the rotational speed decreases it may enhance as well. The maximum torque has afforded 500kNm in the curve for the conditions of 320r/m and 523kW meanwhile the second maximum one has afforded 280kNm in the same for the conditions of 220r/m and 208kW in vehicle with heavy loads. In the end the maximum stability one will maintain in 10kNm with the 320r/m and 523kW in curve of vehicle dynamics. The stabilized torque will reduce about 3kNm to compare with the adjacent two conditions.

The torque may indicate 4kmNm, 3mNm and 2mNm for the time of 0.2s, 0.4s and 0.6s in slope curvature correspondingly. It expresses that the bigger power may afford bigger torque and then rotational speed in this paper.

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