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# Dynamics Modeling between Torque and Rotational Angles & Time Parameters in the Curve of Heavy Vehicle I

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***Abstract***

*As the rotational angle may enhance the torque will have stability scope in curve of vehicle while as time may enhance it will decrease to stability gradually at the same curve. As the power enhances it may enhance correspondingly meanwhile as the rotational speed decreases it may enhance as well. The maxima torque has indicated 3.5mNm in the curve of 320r/m and 523kW meanwhile the second maximum one has attained 2mNm in the same to 220r/m and 208kW. At last, the maximum one will reach in 20mNm with the 250r/m and 208kW with passing time in curve of vehicle dynamics.*

**Keywords:** Modeling; Torque; Rotational Angles; Time; Curve; Heavy Vehicle; Dynamics; Parameters

## Introduction

The power transmission of a heavy vehicle is driven by power on the curve, which is generated by the engine. Therefore, the measurement of torque is the evaluation of the heavy vehicle engine system on the curve, has an important role. This paper studies the overall performance of the heavy vehicle, including whether the curving performance of the heavy vehicle achieves better performance, through the torque and rotation of the heavy vehicle engine. The kinematics of the heavy vehicle takes speed and torque as research parameters and torque as the main purpose of design. Therefore, the organic combination of torque and movement is the real purpose of evaluating the heavy vehicle. At the same time the fatigue performance may become an important trial to proceed. Within its scope the torque will be estimated correspondingly in order to define its life. [1~11] With the increase of horsepower, their dynamic analysis and kinematics become particularly important, such as torque and rotational speed analysis. The torque of a truck is the most important factor. It is 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 these heavy vehicles, the torque with rotational speed and power is directly reflected in its engine function. A good engine function will be achieved in a relatively short time in a curve of vehicle. Thereby, this paper explores whether the data of heavy vehicle design are feasible based on the high power and torque of the heavy vehicle on here, and discusses the status of high power and high torque to meet the needs of future for heavy vehicle development on a slope. In this paper the main torque, rotational angle &time and rotational speed & engine's power has been searched in detail with dynamic modeling for curvature of vehicle. We are searching for the torque stability and maxima condition in one circle of curvature for heavy vehicle, which is our destination of this paper.

## Calculation Processes

The torque and force may be calculated in curve of road. The vehicle tire may rotate toward curve in terms of the schematic graph. Here q is the rotational angle; F is the tire force; ds is displacement; O is curve center; r is the tire radius; R is the radius of curvature. Their formulae will be deduced according to the graph above and they may be shown as follows.

According to energy reservation law in vehicle tire it has

$$w = F\cos\frac{\theta}{2}\cdot s$$

*So it has*

$$dw = \int_{S_1}^{S_2} Fs \cdot d(\cos\frac{\theta}{2})$$

*Here, it has* $w = Fv\int_0^{2\pi} \sin\frac{\theta}{2}\, d\theta$

It has $P = \frac{2\pi Mn}{60}\cos\frac{\theta}{2}$

*ie.* $M = \frac{30PR}{\pi nr\cos\frac{\theta}{2}}$

Here, M is bending moment, Nm; n is rotational speed, r/m; t is the time,s; M is the torque to curvature, Nm.

## 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 rotational angles from 10º to 350º. they may be discussed as below.

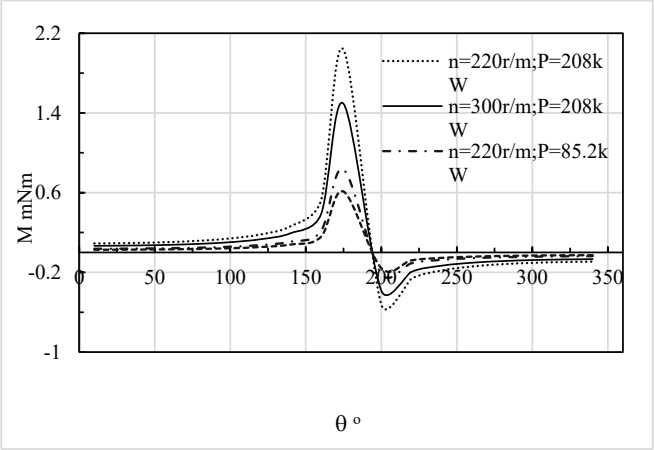


**Figure 1:** The Graph of Torque and Rotational Angle with Various Rotational Speed and Power.

From Figure 1 it may be shown that the torque will increase firstly and then reach maxima decline finally with enhancing the rotational angle from 10º to 350º. The torque may increase from 0.25mNm to 2mNm firstly at the rotational speed to be 220r/m and power to be 208kW. As the rotational speed enhances to 300r/m it may increase to 0.6mNm while the power reduces to 85.2kW it may increase to 20kNm at the maximum periodicity within rotational angle to be 75º~250º. That means that enhancing the rotational speed and reducing power may have reduced the torque. Eventually it will reduce again when the angle becomes from 250º to 350º. The maxima may indicate 2.0mNm, 1.5mNm, 0.8mNm & 0.6mNm for 220r/m & 208kW, 300r/m & 208kW, 220r/m & 85.2kW and 300r/m & 85.2kW correspondingly.

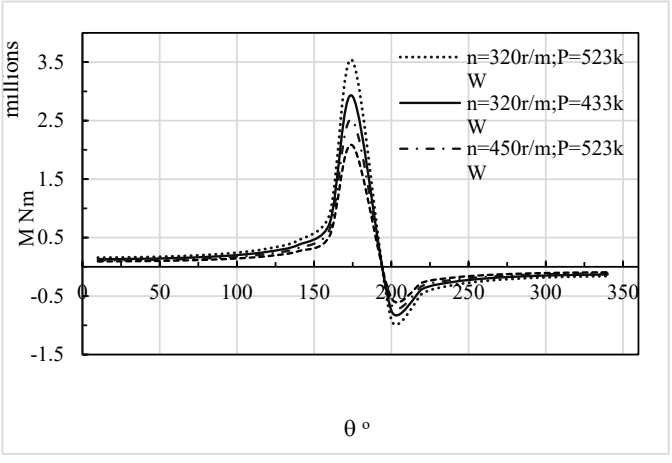


**Figure 2:** The Graph of Torque and Rotational Angles with Various Rotational Speed and Power.

From Figure 2 it may be observed that the torque will increase firstly and then reach maxima decline finally with enhancing the rotational angle from 10º to 350º. The torque may increase from 0.2mNm to 3.5mNm firstly at the rotational speed to be 320r/m and power to be 523kW. As the rotational speed enhances to 450r/m it may increase to 2mNm while the power reduces to 433kW it may decrease to 100kNm at the maximum periodicity within rotational angle to be 75º~250º. That means that enhancing the rotational speed and reducing power may have reduced the torque. Eventually it will enhance again when the angle becomes from 250º to 350º.

The maxima may indicate 3.5mNm, 2.8mNm, 2.5mNm & 2mNm for 320r/m & 523kW, 320r/m & 433kW, 450r/m & 523kW and 450r/m & 433kW correspondingly.

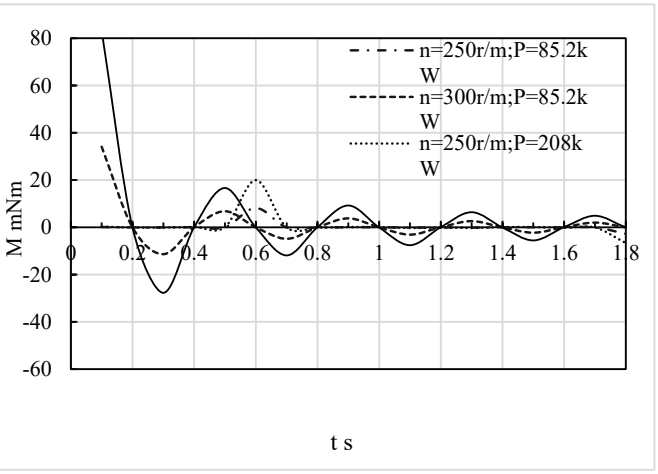


**Figure 3:** The Graph of Torque and Time with Various Rotational Speed and Power in the Curve.

Figure 3 shows that torque may decrease from 26mNm to 16kNm as the time enhances from 0.1s to 1.8s in the curve under the rotational speed to be 250r/m and power to be 208kW for 3m curvature radius. The 10mNm may become the stability status one. When the power decreases to 85.2kW the torque will attain small one to be 4mNm. As for the conditions of 300r/m and 85.2kW the torque may decline from 10mNm to 8mNm. The periodical time is about 0.2s which is constant. Nevertheless, the maximum torque may decline gradually with the time passing which becomes a problem here.

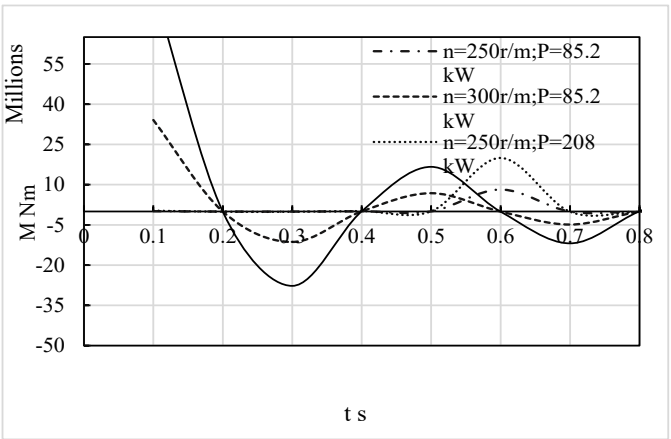


**Figure 4:** The Graph of Torque and Time Amplified from Figure 3 With Various Rotational Speed and Power in Curve of Vehicle.

Figure 4 shows the amplified part from Figure 3 which exhibits the detail status with time from 0.1s to 0.8s in the curve. The torque attains the stability one which may be clarified as following to be 16mNm、8mNm、20mNm and 8mNm in stability scope in turns because of their same & various rotational speed. The torque with adjacent conditions may reach about 5~10mNm. The radius of curvature is 3m which is supposed in this paper.

Overall, as the rotational angle may enhance the torque will have stability scope in curve of vehicle while as time may enhance it will decrease to stability gradually at the same curve. As the power enhances it may enhance correspondingly meanwhile as the rotational speed decreases it may enhance as well. The maximum torque has attained 3.5mNm in the curve of 320r/m and 523kW, on the other hand the maximum one has attained 2mNm in the same to 220r/m and 208kW.

## Conclusions

As the rotational angle may enhance the torque will have stability scope in curve of vehicle, meanwhile as time may enhance it will increase to maxima gradually at the curve. As the power enhances it may enhance correspondingly, meanwhile as the rotational speed decreases it may enhance as well. The maxima torque has attained 3.5mNm in the curve of 320r/m and 523kW, meanwhile the second maxima one has indicated 2mNm in the same of 220r/m and 208kW. At last, the maximum one will reach in 20mNm with the 250r/m and 208kW with time passing in curve of vehicle dynamics.

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