

# The Simulation among Kinematic Properties of Crank linkage of Engine in Vehicle

Run Xu\*

Gyeongsang National University, Metallurgical Engineering Dept, Chinju 52828, Korea

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\*Corresponding author: Run Xu

## Abstract

The torque will be in proportion to the crank and linkage length. That may be fitted to the stroke ratio  $\gamma$  well. The bigger the  $\gamma$  is the bigger the torque is. The crank acceleration and block angle will be low when the  $\gamma$  becomes big. The linkage acceleration and speed may incline as the stroke ratio and rotation is big. The movement will be big when the stroke ratio is small and the rotation is inclining on the crank linkage mechanism in vehicle

**Keywords:** property, simulation, crank linkage, vehicle, engine, kinematic.

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## INTRODUCTION

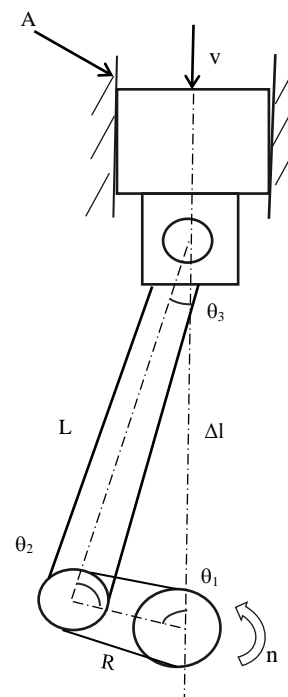
The crank linkage in engine of vehicle is important mechanism so the simulation may be done to search its properties and their effective value further and details. Because its important role in engine the optimum parameters have been solved to find the intrinsic relations among them is very significant currently [1, 2]. However up to now the Kinematic equation of Lagrange formula has been a little status so it is necessary to establish the simulation to analyze the Kinematics of it. Although some searched the simulation to multibody system it is confined at three ordinations profile. They didn't search more detail to every parameter [3] so in this study the role of parameters with movement, linkage angle and acceleration has been investigated with Lagrange formula and try to find the intrinsic relationship among them.

In this study the parameters including properties of engine crank linkage have been investigated in detail with Lagrange formula in multibody system. It is found how the acceleration and angular speed play a role and with their other parameters link. Those properties may be clarified through drawing in order to compare with the torque. It is hoped that the effect factor which affect the torque further through comparing their value with torque.

In short the torque may be inclined has been our destination and other parameters can promote the

torque through regulating the parameter value. We try to find that the parameter deeds to improve the general torque value.

## Simulatio



**Fig-1: The kinematic of crank linkage linkage length in the engine of vehicle.**

According to Figure 1 which is kinematic graphs on the crank linkage in engine in vehicle. It is supposed that crank R=45mm~60mm , crank linkage L=190mm~210mm. This is the engine driving crank

The Lagrange equation is

$$\frac{d}{dt} \left( \frac{\partial E_k}{\partial \dot{q}_i} \right) - \frac{\partial E_k}{\partial q_i} + \frac{\partial E_p}{\partial q_i} = F_i, (i=1,2,\dots,n) \tag{1}$$

Here  $E_k$  is kinetic of system;  $E_p$  is potential energy of system;  $q_i$  is generalized coordinate, it is a group of independent parameters that can define mechanical system movement;  $F_i$  is generalized force,  $q_i$  is a angular displacement or linear displacement; n is system generalized coordinate.

According to Lagrange Formula it has

$$F_r = m_3 \dot{v}_3 + I_2 \dot{\omega}_2 + I_2 \dot{\omega}_3 + I_1 \dot{\omega}_1 - m_3 v_3 \dot{v}_3 - I_2 \omega_2 \dot{\omega}_2 - I_2 \omega_3 \dot{\omega}_3 + I_1 \omega_1 \dot{\omega}_1 + m_3 g \tag{2}$$

This is the dynamic equation for crank linkage of multibody system.  $\omega_1, \omega_2$  and  $\omega_3$  is sliding block, crank linkage and crank angle respectively.

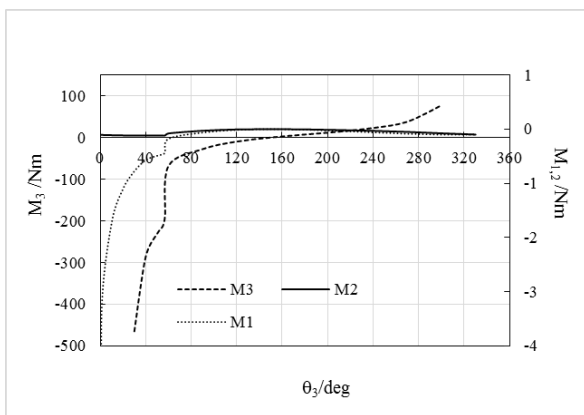
In crank linkage of multi body system it has

$$F = \sum_{k=1}^m \left[ F_k \frac{\partial s_k}{\partial q_i} \cos \alpha_k \right] + \sum_{j=1}^n \left[ M_j \frac{\partial \phi_j}{\partial q_i} \right] \tag{3}$$

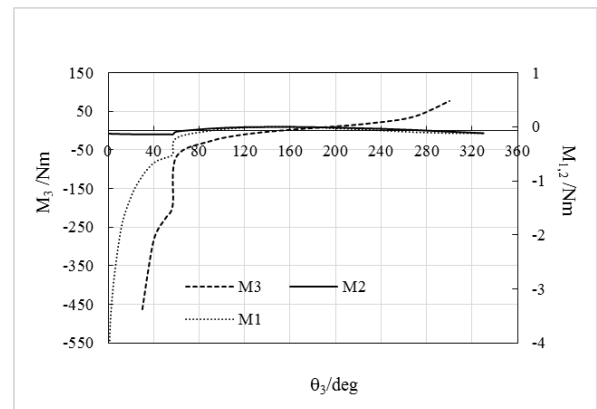
This is generalized force equation. Here q is generalized coordinate;  $\dot{q}$  is velocity of q.

### DISCUSSIONS

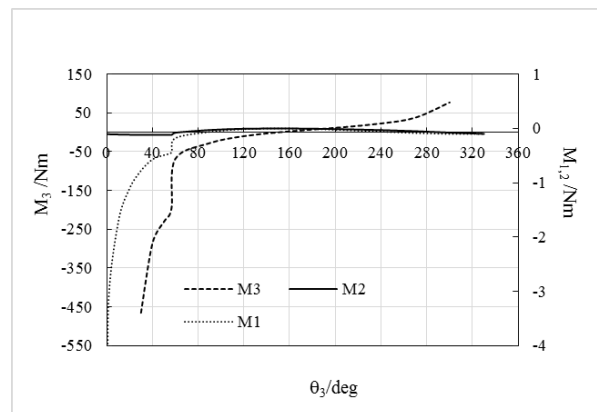
The torque will be in proportion to the crank and linkage length in Figure 2(a~c). That may be fitted to the stroke ratio  $\gamma$  well. The bigger the  $\gamma$  is the bigger the torque is. The crank acceleration and block angle will be low when the  $\gamma$  becomes big as seen in Figure 3(a~c).



(a) 790r/m, R=45mm & L=210mm

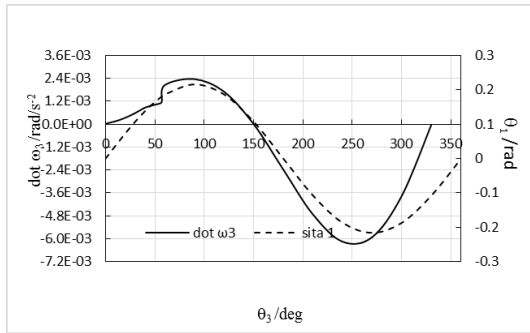


(b) 790r/m, R=53mm & L=210mm

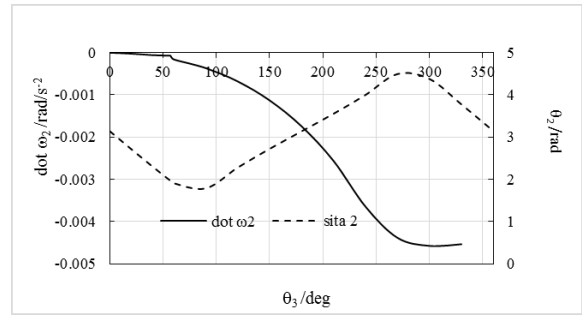


(c) 710r/m, R=45mm & L=190mm

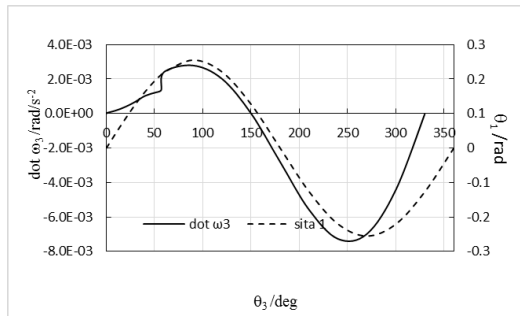
Fig-2: The relationship between torque and crank angle  $\theta_3$  in crank linkage with the mass of 0.35Kg, the rotation and R & L on engine.



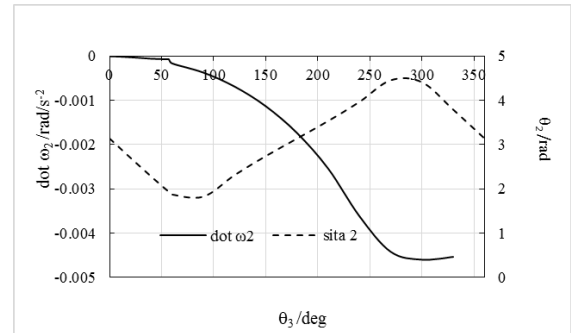
(a) 790r/m, R=45mm & L=210mm



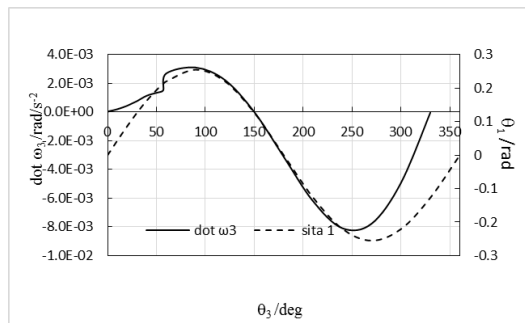
(b) 790r/m, R=45mm & L=210mm



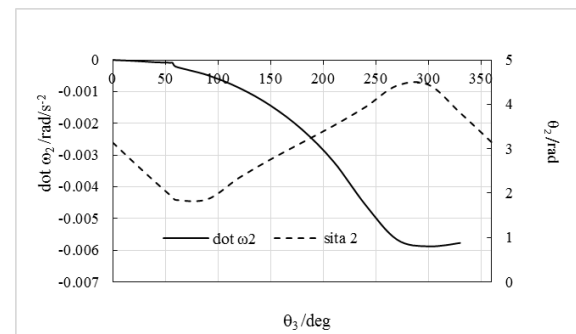
(b) 790r/m, R=53mm & L=210mm



(c) 790r/m, R=53mm & L=210mm



(c) 710r/m, R=53mm & L=210mm

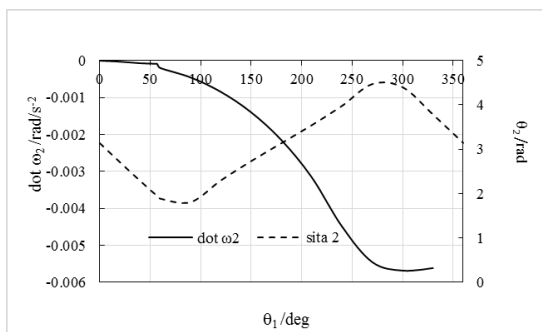


(d) 700r/m, R=60mm & L=210mm

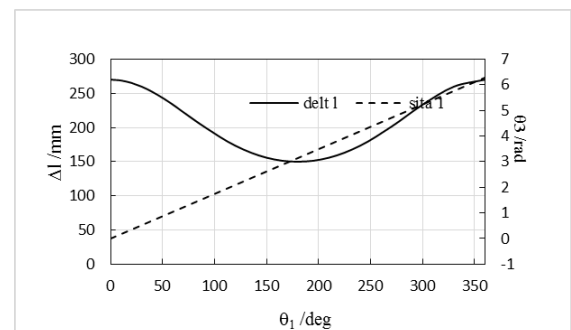
**Fig-3: The relationship between angular acceleration 3 and crank angle 3 in crank linkage with time in the rotation and R & L on engine.**

**Fig-4: The relationship between acceleration and linkage angle 2 in crank linkage with time in the rotation and R & L on engine. In Figure 4 the angular acceleration will be big when the stroke ratio is big and the rotation is inclining on the crank linkage mechanism in vehicle from Figure 1(a-d).**

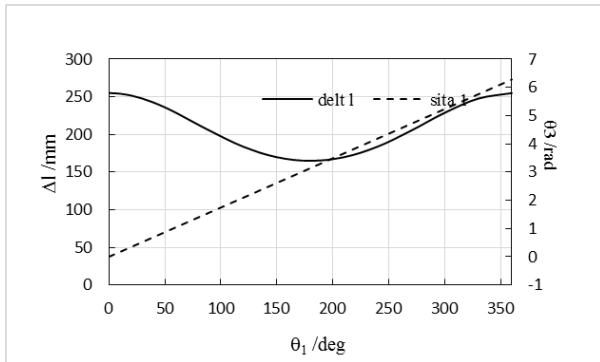
It is supposed that crank shaft speed is 700r/m, 710r/m, 790r/m respectively in this study. After Lagrange transformation the force and torque may be solved it is not concluded in here. Only other detail parameters relation has been drawn as below in this multibody system of engine.



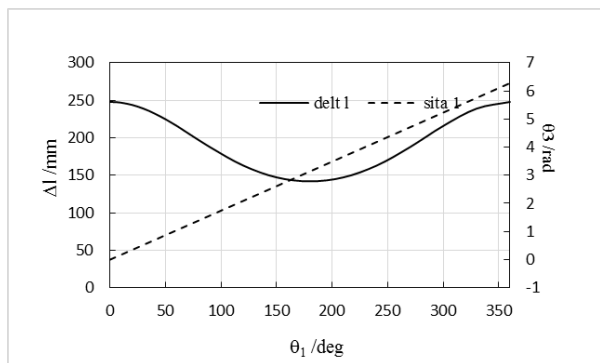
(a) 710r/m, R=45mm & L=190mm



(a) 700r/m, R=53mm & L=210mm



(b) 790r/m, R=45mm &amp;L=210mm



(c) 790r/m, R=53mm &amp;L=195mm

**Fig-5: The relationship between distance and linkage angle  $\theta_1$  in crank linkage with time in the mass of 0.35Kg, the rotation and R & L on engine. The movement will be big when the stroke ratio is small and the rotation is inclining on the crank linkage mechanism in vehicle from Figure 5(a~c).**

## CONCLUSIONS

The torque will be big as the ratio of crank length and linkage is high. The crank acceleration and block angle will be big as the ratio is small. These are the conclusions searching in this paper.

The angular acceleration will be big when the stroke ratio is big and the rotation is inclining on the crank linkage mechanism in vehicle. The movement will be big when the stroke ratio is small and the rotation is inclining on the crank linkage mechanism.

## REFERENCES

1. Zhihua Li etc, The Dynamics Solving Method of Flexible Joint Robot Based on Quantized State System, Journal of Mechanical Engineering. 2020,56(3): 121.
2. Yong Zhang, Jinlong Qin, Tian Meng& Kui Gou. Dynamic Simulation of Crank Linkage Mechanism of Multibody in Gasoline Engine, Journal of Chongqing University of Technology (Natural Science). 2018 32(11) : 1.
3. Run X. The Dynamics &Torque and Force-Angle Relation on Velocity of Hammer with Lagrange Equation in Robotic Arm I , Social Science learning Education Journal. 2020, 5 ( 09 ) September, 335-339, DOI: <https://doi.org/10.15520/sslej.v5i07.2715>.