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The Relationship of Properties and Variable Mass of Block on Crank Linkage Mechanism in Multibody System

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Abstract

The multibody relationships between Parameters and angles in crank linkage is investigated in this study and found little force and big speed formed in the dynamics with Lagrange formula in the condition of 720r/m and variable mass of sliding block. When the mass is big the force may incline. The speed will attain the maximum value of 120m/s and acceleration reaches 0.1mm/s2. The torque is biggest with 300Nm on crank and then 5Nm on block and 0.5Nm on linkage turns. As the block mass becomes big the acceleration and speed will be big too.

Keywords: Relationship; Force and time; Lagrange formula; Crank linkage; Crank; Crank linkage; Vehicle

Introduction

The crank linkage is an important mechanism in vehicle which includes crank, crank linkage and sliding block on engine so the research will be proceeded on them is necessary method to calculate with modeling in recent study. So this paper will search the detail database to establish the formula to solve it further [1-3]. The dynamics can solve the key problem of intrinsic relationship between force and time in engine which can express the detail behaviour to the crank linkage force analysis for us to find intrinsic things. As recent the vehicle has been grown rapidly in world so the most significant engine part of crank linkage will play more and more roles in future. The fatigue life will be key to its span life so the force change with time of rotation will be important data for us to search deeply. The force behavior must be established to further clarify the fatigue role and play a key role. Since the time limits the fatigue life wouldn't be searched here we only play to establish dynamic modelling in terms of Lagrange formula to crank linkage mechanism. We try to find role of force formed on sliding block mass at certain rotation speed and time in order to find its maximum force and its stability [4-6]. We want to find the mass conditions which causes the bigger force for engine of crank linkage so it is searched on its status in this study. On the other side the shaft rotation is studied too to look for the appropriate effects. As for multibody system dynamics the Lagrange formula is used to analyse it so it is sophisticated and complex to establish the formula. The result has been deviation usually. In this paper the crank linkage system is simulated with Lagrange formula to look for the deviation scope in vehicle engine.

Modelling and Calculation

According to Figure 1 and 2 which is kinematic graphs on the crank linkage in engine in vehicle. From Figure 2 it is supposes that crank R=60mm, crank linkage L=210mm. This is the engine driving crank linkage, Δ Δl=lmax-lmin. A is sliding block and cylinder wall; q1, q2 and q3 is sliding block, crank linkage and crank angle respectively; v is its speed; n is shaft rotation.
It has

$$\Delta l = \sqrt{L^2 + R^2 - 2LR\cos\left[\pi - \arcsin(\frac{R}{L}\sin\theta_3) - \theta_3\right]} \quad (1)$$

Here $\theta_3 = 2\pi nt/60$

According to Lagrange formula

$$\frac{d}{dt}\left(\frac{\partial E_K}{\partial \dot{q}_i}\right) - \frac{\partial E_K}{\partial q_i} + \frac{\partial E_P}{\partial q_i} = F_i \qquad (2)$$

The formula (2) is the crank linkage dynamic formula in terms of Figure 2. Here rotary inertia is

$I_1 = \frac{1}{3}m_1 l_1^2; I_2 = \frac{1}{3}m_2 l_2^2$ (3)

It is supposed that m_1=0.6Kg; m_2=2Kg; m_3=0.25Kg.

And $\omega_1^t\ \theta_1$ (4)

So it has $\omega_1^{\cdot}\ t^2\theta_1$ (5)

The same as above it has

$\omega_2^{\cdot}\ t^2\theta_2$ (6)

$\omega_3^{\cdot}\ t^2\theta_3$ (7)

And $\vartheta_1^{\cdot}\ t^2\ l\ L\ R$ (8)

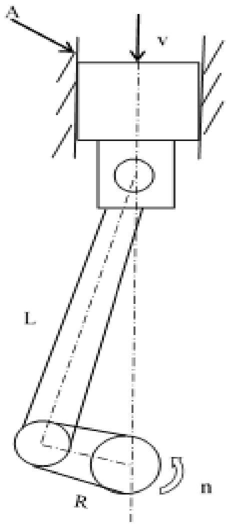


Figure 1: *The kinematic of crank linkage length in the engine of vehicle.*

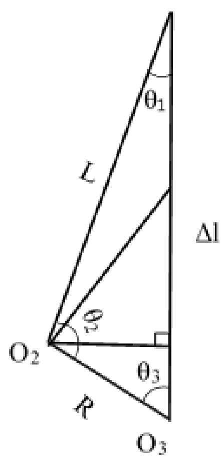


Figure 2: *The kinematic of crank linkage mechanism in engine of vehicle.*

Discussions

Figure 3 shows the curve between force and time under n=700r/m. This indicates that the maximum force in the crank linkage is up to 4.5N ie. 4.5KgF and the force maintains a line with the increase of time. It is little relation to the crank length R=60mm and linkage L=210mm in terms of supposed conditions. The periodic time is 4E-2s in 700r/m, it means that all the periodic time is the same with variable block mass. Figure 3 shows that the force becomes linear likely from 0 to 4.3E-2s which is the same as θ3=0~360º. The size is larger than the one at 0.45Kg and then 0.4Kg &0.35Kg. The force is only several N expresses the little force is needed in the linkage. The force is used instantaneous time within one cycle to gain the simulation results.

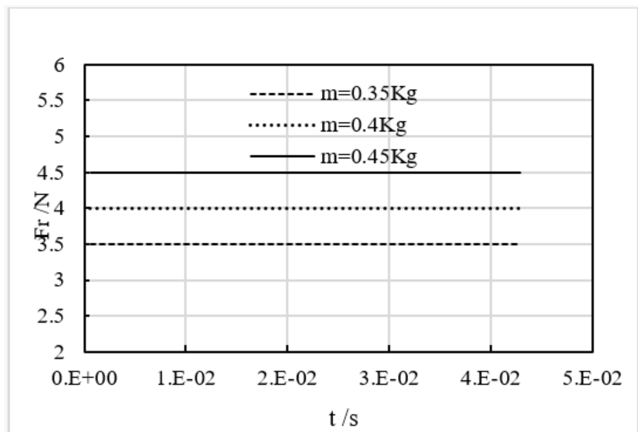


Figure 3: *The relationship between force and time in crank linkage with the rotation of 700r/m and regulating from 0.35Kg to 0.45Kg mass sliding block on vehicle.*

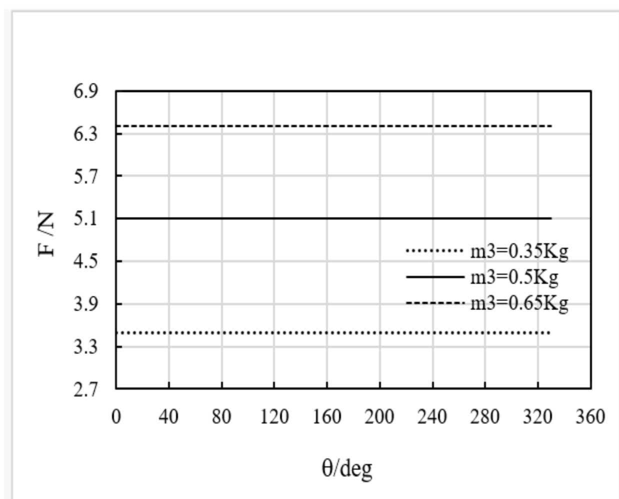


Figure 4: *The relationship between force and crank angle in crank linkage with the rotation of 720r/m and R=60mm & L=120mm on vehicle.*

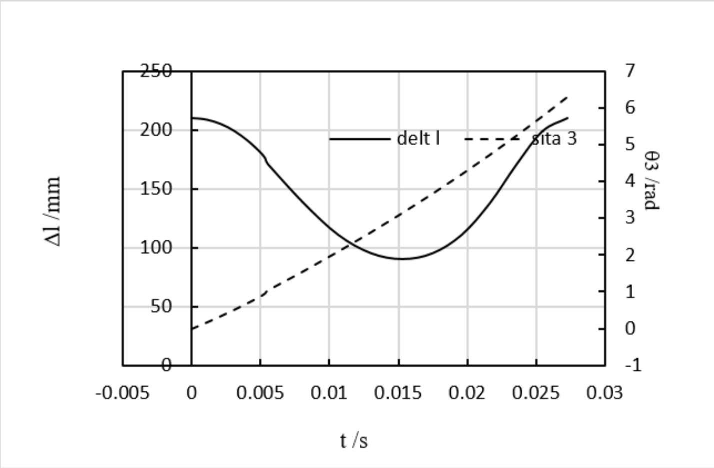


Figure 5: *The relationship between distance and crank angle 3 in crank linkage with time in the mass of 0.35Kg, the rotation of 720r/m and R=60mm & L=150mm on vehicle.*

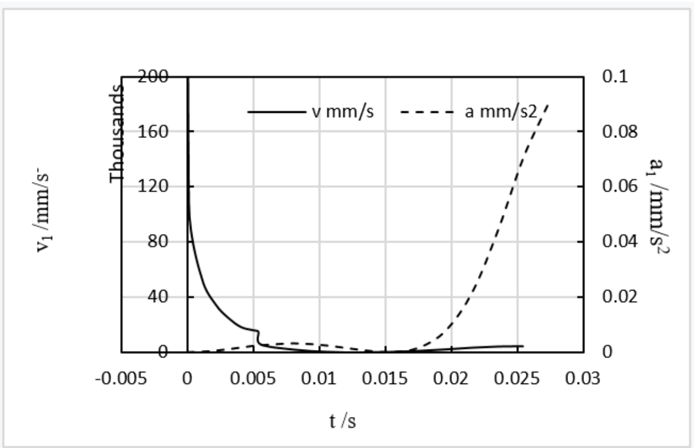


Figure 6: *The relationship between speed and acceleration in crank linkage with time at the mass of 0.35Kg, rotation of 720r/m and R=60mm & L=150mm on vehicle.*

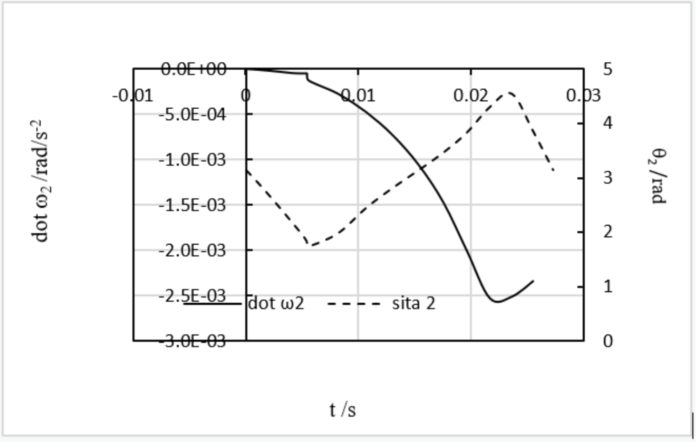


Figure 7: *The relationship between acceleration and crank angle 2 in crank linkage with time in the rotation of 720r/m and R=60mm & L=150mm on vehicle.*

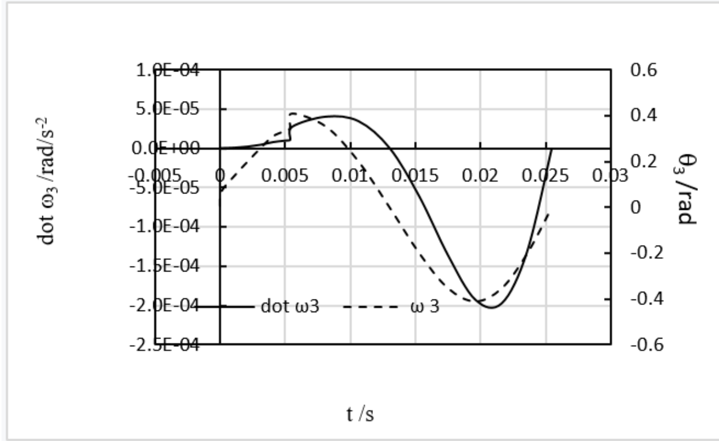
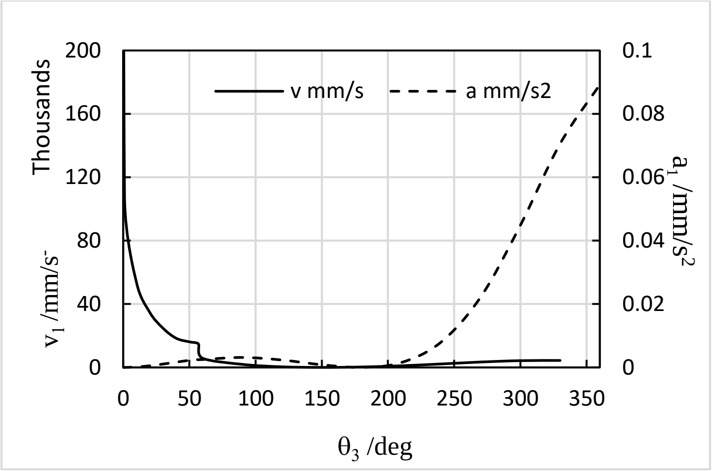
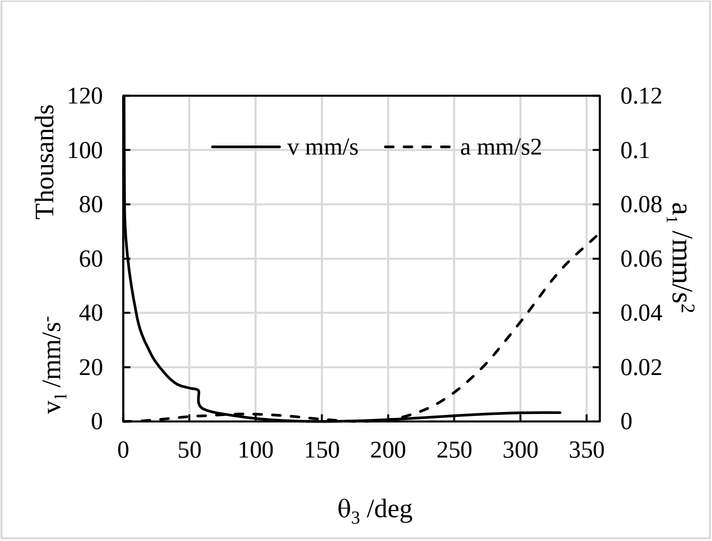


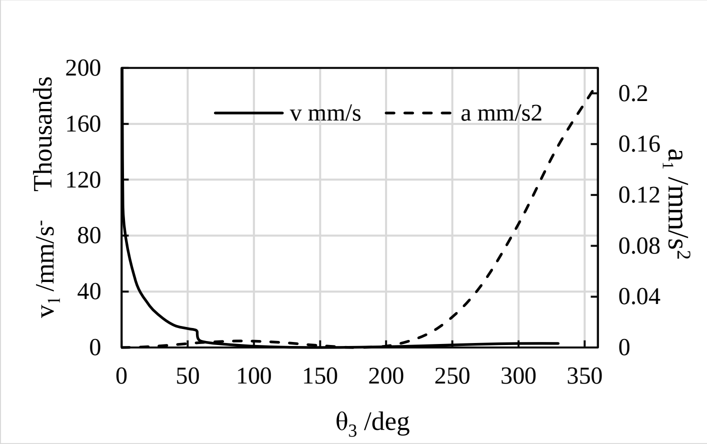
Figure 8: *The relationship between angular acceleration 3 and crank angle 3 in crank linkage with time in the rotation of 720r/m and R=60mm & L=150mm on vehicle.*



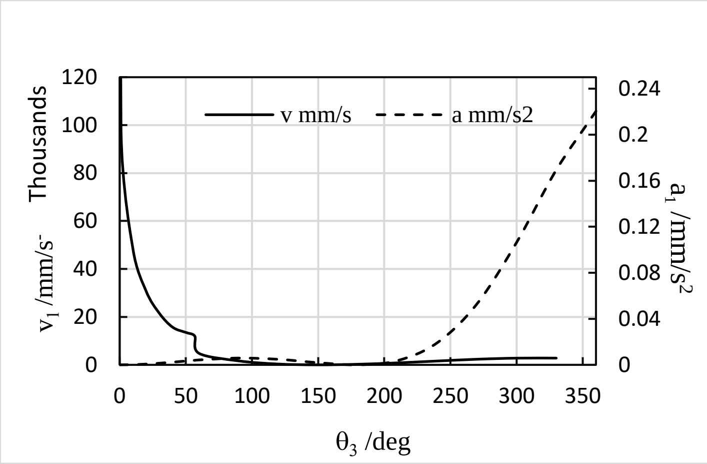
(a) 700~890r/m and R=40mm & L=210mm



(b) 700~1080r/m and R=45mm & L=190mm



(c) 720r/m and R=60mm & L=150mm



(d) m_b=0.5Kg, 720r/m and R=60mm & L=210mm

Figure 9: *The relationship between speed and acceleration in crank angle linkage with time at the mass of 0.35&0.5Kg、rotation and R& L.*

In Figure 3 the force will be shown in one cycle of crank angle. It is found that the no variable trend may be gained respectively in this cycle. The maximum force can be beyond 4.5Kg at the end of 4.3E-2s. The same trends with this figure are gained in Figure 7&8 except that the inclining force will be formed here. For example the biggest one will attain 75N and 110N at the end of 4.3E-2s. It expresses that the force with mass sliding block inclining to 7.6Kg & 11.4Kg may incline too. The turn points in these figures range from 18N to 37N, 55N which explains that the force will be inclined two times.

In Figure 4 the force will distribute a line. They are different with amplitude. The first one exhibits 2.5N whilst the second is 3.5N and the third is 4.5N within a cycle in Figure 4~6 at the rotation of 720r/m. The force may incline as the time inclines from 0.2Kg、0.35Kg to 0.45Kg. They exhibit the constant value within the whole cycle. The system force may be several N in terms of these three figures which expresses the little force can be formed in crank linkage of vehicle and it can save cost too. In Figure 4 the force has linear one as the crank angle inclines in rotation of 720r/m & mass of 0.35Kg. The biggest one is 6.4N in all the angle with mass of 0.65Kg and the smallest is 3.4N with mass of 0.35Kg. It expresses that small mass may cause low force.

From Figure 5~ Figure 8 the curves between parameters and time can be shown within one cycle in crank linkage of engine. The sliding block speed is high reaching 120m/s firstly and then becomes low reaching 0.015m/s at 0.005s steeply. The $\dot{\theta}_2$ and $\dot{\theta}_3$ can be low too which is since the constant rotation supposed here. In Figure 9 it expresses that the big block speed with 120m/s is formed with angle of crank increasing. From Figure 9 it is known that acceleration will be big when block mass attains 0.5Kg which is bigger than 0.35Kg. The speed is the same behavior as acceleration. That's meaning that the speed has been big when the block one is 0.5Kg. The maximum acceleration attains 0.23mm/s^2 whilst the maximum speed arrives 100m/s. it means that the speed is related high and the acceleration is little due to the little speed change within a cycle.

In short the torque arrives maximum 300Nm on crank and then 5Nm on sliding block & 0.5Nm on linkage in turn. So the crank sustains the main torque and then slide block & crank linkage. The torque ratio of crank and block is 60 times whilst the ratio of sliding block and crank linkage attains 10 times. So there is the effective turn with Crank> sliding block>crank linkage.

In general the force of sliding block may be inclined through declining the rotation and inclining its mass. In details the demanded one may be reached with big size if there are defined requirement. The second one is playing important role so it can be

Conclusions

1. The torque will attain the maximum 300Nm on crank and 5Nm on block 0.5Nm on linkage.So there is the effective turn with Crank> sliding block>crank linkage.
2. The highest is the speed of block with 120m/s and angular speed of crank linkage arrives 750rad/s at the 0º and 20º respectively. The crank angular speed is low with 30~-10 rad/s.
3. As the block mass is big the speed and acceleration will become big.

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