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Dynamics modeling for crane linkage mechanism in heavy vehicle

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Abstract. The dynamics modeling has an important role in optimizing design and decreasing cost, hence it has been built for searching for the intrinsic relationship among its parameters in crane linkage mechanism of heavy vehicle in light of this paper. The speed and displacement may change with sine and cosine shape periodically for crane linkage mechanism of vehicle in light of this paper modeling. The maximum speed may indicate ±2km/s and minimum one may provide ±180m/s. Meantime the maximum acceleration will indicate ±1Mm/s^2, ±270k/m^2, ±44km/s^2 &±5.8km/s^2 with the rotational angle to be 80º and 170º correspondingly in this paper. The former two has R=70mm &L=150mm and low rotational speed with n=500r/m and 1,000r/m while the latter two may have R=80mm &L=160mm with n=2,000r/m and 3,000r/m. They may enhance with increasing crane radius R and linkage length L respectively for the mechanism according to this modeling. The biggest acceleration effectiveness will be controlled with rotational speed. The excellent results are acquired in this paper in light of dynamics modeling.

Keywords. Modeling; dynamics; parameters; vehicle; crane linkage mechanism; one circle; heavy vehicle.

1. Introduction

The vehicles with the clean、non noise & artificial intelligence are available. It had connected interaction net with flattening、decentralization & establishment of cooperatives. As recent the vehicle has been grown rapidly in world so the most significant part of crank linkage mechanism will play a more and more roles currently. The fatigue life will be key to its span life so the force change with crane rotational angle of rotation will provide important data for us to search deeply. The force behavior must be established to further clarify the fatigue role for playing a key role. Since the rotational angle limits the fatigue life wouldn't be searched here so that we only play to establish one circle dynamic modelling in terms of integral methods for crank linkage mechanism. We try to find role of the force formed for sliding block mass at certain rotational speed and power in order to find its maximum force and its stability. The stability may play an important role for designing and evaluating the crane linkage mechanism. It can provide the main value for measuring vehicle properties and life.

The vehicle design which has bigger load than general ones as an important work has significant role for one circle of crane linkage mechanism in heavy vehicle. For example, the new car, be needed to regulate which fits to the demand of purchase from customer. Therein the main parameters are the key of the designing vehicle. Mercedes-Benz's A45 AMG has a 2.0T engine of 360Ps. In terms of the demand the whole design may be proceeded with modeling in advance. Furthermore, the connecting with the fact will become more and more significant now. Not only this may decrease the design time but also it may cause the reality effect. Through the modeling it could see to preforming effect, meantime the defect could be observed which is our destination. The defect wants to be found in advance while it could be detected by program for us to mend fitly so it is very important work for us.

So, the modeling of new design has been established for decreasing cost and enhancing the optimum. In special the new function vehicle is the new construction product. It is needed to match parameters which may be proposed for designing optimum. Therein the dynamic equilibrium is a new way to design the new car that can connect with virtual reality. Only the dynamic equilibrium could we promote and improve our product properties more completely and collaboratively. [1~18].

Overall, the new vehicle has been designed through its modeling which is established by our professor. So the parameter has been proposed and the best constants are provided in regard to optimized designing which must afford the best conditions. We want to propose the power and rotational angle etc. parameters which causes the bigger force for crank linkage so it is searched on its properties in this study. On the other side the crane rotation is studied as well to observe the appropriate effects. As for that system the integral methods is used to analyze dynamics so it is sophisticated and complex to establish the formula. The crank linkage system is deduced with integral methods to look for the stability scope for one circle of crane linkage mechanism in heavy vehicle whose power may provide from 225kW i.e. 306hp to 355kW i.e. 483hp and length for various crane length, linkage length, power & piston gravity etc. parameters in this study.

2. Modeling establishment

In principle of crane linkage mechanism, it has been computed as below. In this study it has been supposed that R is crane radius, m; L is linkage length, m; θ is the crane rotational speed, º; ΔL is the displacement of piston in engine; t is the time, s; v is the piston speed, m/s; a is the acceleration, m/s^2; n is craning rotational speed, r/m.

Since it has below formula from literature.

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

Derivate above formula it has

$$v = \frac{d\Delta L}{dt} = \frac{\pi n R^2 sin\left[\pi - arcsin(\frac{R}{L}sin\theta) - \theta\right] cos\left[\frac{1}{\sqrt{1-(\frac{R}{L}sin\theta)^2}} - \frac{\pi n}{30}\right]}{30\sqrt{R^2+L^2-2LRcos\left[\pi - arcsin(\frac{R}{L}sin\theta) - \theta\right]}} \quad (2)$$

It has $a = \frac{d^2\Delta L}{dt^2}$ (3)

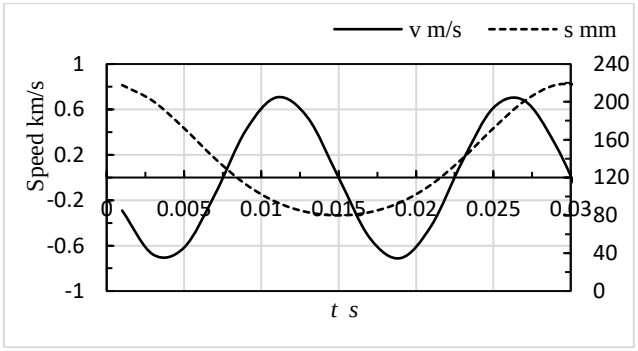
Those are the piston speed and acceleration formulas.

Table 1. The parameters for crane radius R and linkage length L in vehicle engine

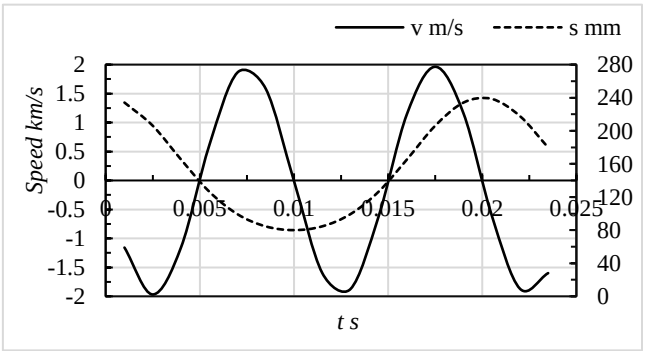
Items / No.	R mm	L mm	Stroke ratio	$q_1$max °
1	80	160	0.50	30
2	70	150	0.47	28

3. Discussions

Table 1 shows that the crane radius and linkage length conditions will afford for vehicle engine. They may indicate that q_1 presents cylinder angle with linkage length; stroke ratio presents R/L; θ is the crane angle as q_1 is maximum. The lower stroke ration will become the better properties will be afforded. The best one will afford 0.47 with crane radius 70mm and linkage length 150mm. In light of above derivation results the cylinder piston speed and displacement may be calculated as below. Figure 1(a&b) shows that the piston speed and displacement indicate sine and cosine shape periodically with rotational angle of crane for different crane radius, linkage length and various speed in heavy vehicle.



(a) R=70mm; L=150mm; n=2,000r/m



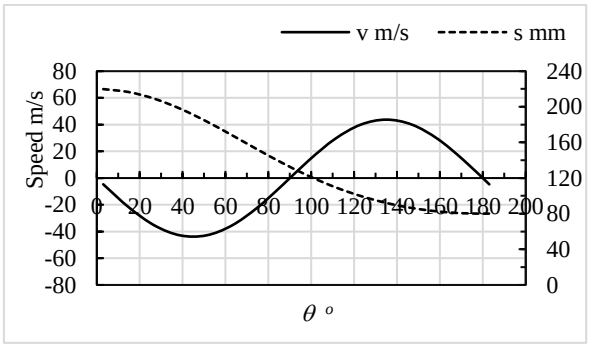
(b) R=80mm; L=160mm; n=3,000r/m

Figure 1. The speed and displacement with time for various rotational speed for R=80mm &L=150mm

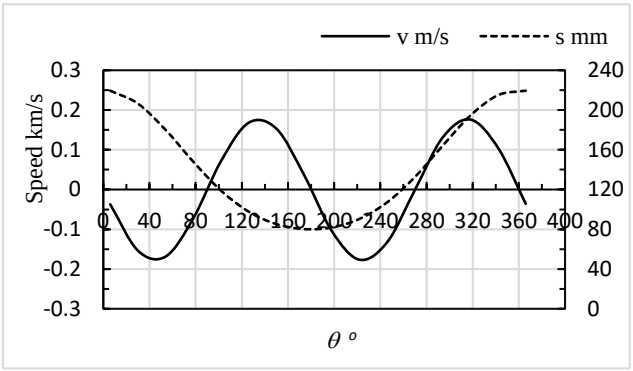
In Figure 1(a&b) the piston speed and displacement exhibits sine and cosine shape periodically. The periodical time may provide 0.015s and 0.01s correspondingly in light of those figures. The maximum ones may indicate ±2km/s and 240mm~80mm whilst they may exhibit the minimum ±0.7km/s and 220mm~80mm as shown in in Figure 2(a &b)

correspondingly in light of the conditions for various R=70mm~80mm and L=150mm~160mm and rotational speed 2,000r/m~3,000r/m.

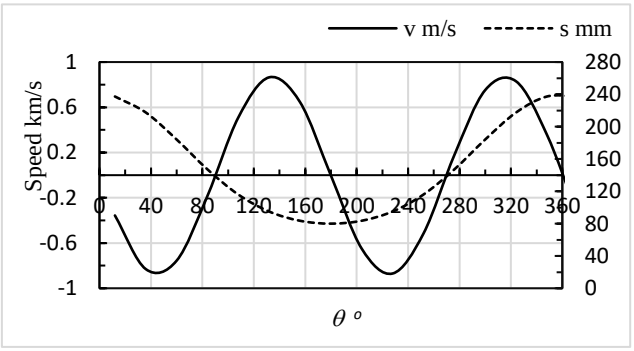
They may enhance with increasing crane radius R and linkage length L respectively.



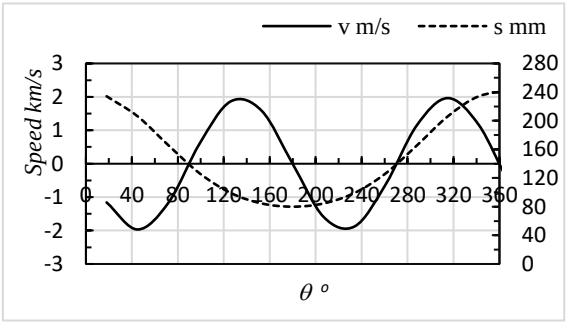
(a) R=70mm; L=150mm; n=500r/m



(b) R=70mm; L=150mm; n=1,000r/m



(c) R=80mm; L=160mm; n=2,000r/m

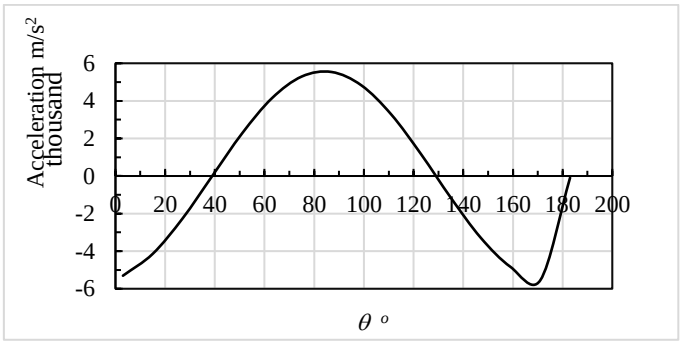


(d) R=80mm; L=160mm; n=3,000r/m

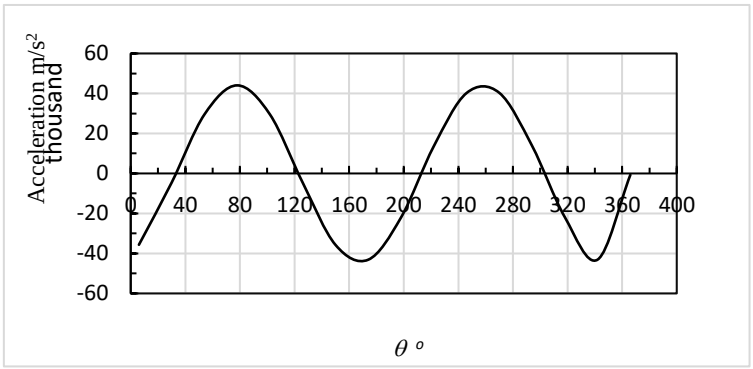
Figure 2. The speed and displacement with rotational angle for various rotational speed 500r/m~3,000r/m in engine of vehicle

In Figure 2(a &b) the piston speed and displacement may indicate sine and cosine shape periodically with crane rotational angle and R=80mm~70mm & L=150mm~160mm for crane linkage mechanism of vehicle. They have the same amplitude with the same ones mentioned as above each other. The difference may indicate the zero with the angle becomes 40º and 140º correspondingly since the higher rotational speed has been owned in later. In

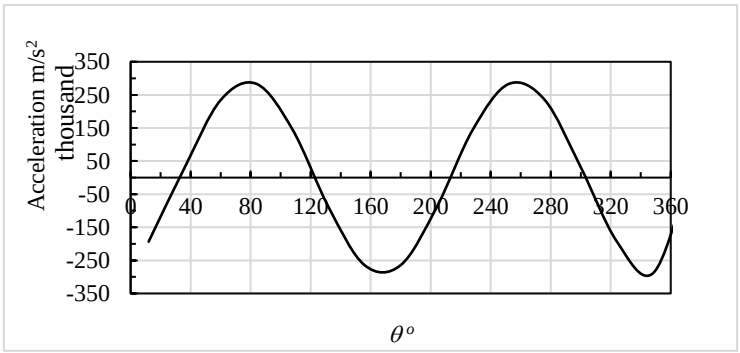
Figure 2(a~d) the speed and displacement will indicate small ones to be ±44m/s, ±180m/s, ±0.8km/s and ±2km/s and 230mm &240mm~80mm respectively. Additionally, as shown in Figure 2(a~d) the period for piston speed may provide 190º and 380º etc. and for its displacement may afford 360º correspondingly.



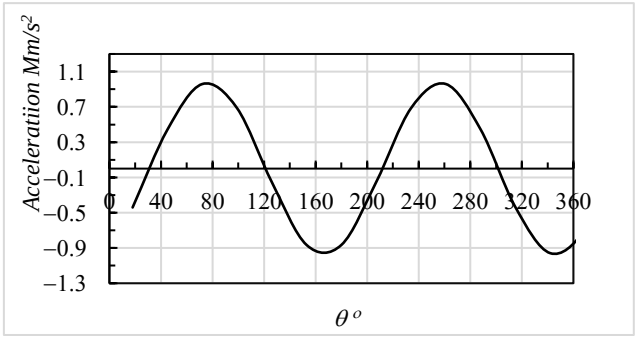
(a) R=80mm; L=160mm; n=500rm



(b) R=80mm; L=160mm; n=1,000rm



(c) R=70mm; L=150mm; n=2,000rm



(d) R=70mm; L=150mm; n=3,000rm

Figure 3. The acceleration and angle with various rotational speed and crane radius R and linkage length L for heavy vehicle

In Figure 3(a~d) the acceleration will maintain sine shape with enhancing time. It may indicate ±5.8km/s^2, ±44km/s^2, ±270km/s^2 and ±1Mm/s^2 with the periodical angle to be 80º, 170º etc. In turns respectively for the conditions to be

marked. The biggest acceleration effectiveness will be controlled with rotational speed primarily. That expresses that the bigger the rotational speed may be the higher the acceleration will indicate.

In short, the piston speed may lessen with declining stroke ratio from R and L to be 80mm~160mm to 70mm~150mm meanwhile the displacement will maintain in 230mm~240mm. The piston speed and displacement have the maximum value. The former may provide sine speed whilst the later may afford the cosine one. The displacement changes according to corresponding to the theoretical values very well while the speed changes as well for crane linkage mechanism in vehicle engine.

4. Conclusions

The piston speed and displacement may change with sine and cosine shape periodically for crane linkage mechanism of vehicle in light of this paper modeling. The maximum speed may indicate ±2km/s and minimum one may provide ±180m/s. At the same time, the maximum acceleration will indicate ±1Mm/s^2, ±270k/m^2, ±44km/s^2 &±5.8km/s^2 with the rotational angle to be 80º and 170º correspondingly in this paper. The former two has R=70mm &L=150mm and low rotational speed with n=500r/m and 1,000r/m while the latter two may have R=80mm &L=160mm with n=2,000r/m and 3,000r/m. They may enhance with increasing crane radius R and linkage length L respectively for the mechanism according to this modeling. The biggest acceleration effectiveness will be controlled with rotational speed.

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