Design Optimisation of Counter Weight of Front End Loader Through Dynamic Mass Balancing.

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***Abstract* — In the field of heavy engineering industries like half road, construction and mining vehicles the mass balancing during dynamic situation has critical role in overall vehicle performance like traction, weight lifting and stability. This phenomenon is highly depends on mass distribution of the vehicle. The mass balancing is controlled by adding counter weight to the rear axle. The counter weights that are added to the is also an addition load and which is an fixed or dead mass that cannot handle the balancing at dynamic condition so that the ineffective counter balancing will reduce the vehicle performance. In this paper an auto adjustable counter weight mechanism is introduced to balance the dynamic reactions created by the movement, lifting of boom or due to road bumps for a front end loader vehicle. For the front end loader vehicle the maximum lifting mass depends on the counter weight these weight added to its rear axle to avoid rear lift.**

This load is based on maximum load when bucket is full and in horizontal condition. Hence even when operating below the maximum load the rear axle is loaded with the full counter weight which increases the tyre friction and stress on the rear axle components so an auto adjustable sliding rear counter weight on a moment arm fixed below the centre line of rear axle shaft will allow to use reduced counter weight to balance maximum front load by moving the weight rear ward on the moment arm with respect to the orientation of loader boom cylinder with respect to the front axle. By this mechanism overall vehicle performance and dynamic stability can be increased.

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Index Terms – Adjustable counter weight, dynamic balancing, FEL stability, mass balancing mechanism.

I. INTRODUCTION

Construction machines, sometimes referred to as engineering vehicles or earth movers, are basically a class of self-propelled machines designed for use in civil and mining activities. The work in this paper concerns a special class of construction and mining machines, the front end loader. This vehicle is essentially a type of tractor equipped with permanently attached, front mounted lifting arms operated by hydraulic cylinders. Unlike vehicles designed primarily for transport, the wheel loader is built without any axle suspension. The rear wheels are attached directly to the vehicle body, and the front axle is allowed to oscillate around the longitudinal axis, thus allowing all wheels to maintain contact with the round. An example of a medium sized wheel loader is shown in fig 1.

Figure 1

FEL vehicle mass:

Modern front end loaders vehicle range in mass, from 2 000 – 3 000 kg compact machines to large mining loaders of more than 10000 kg total mass. The Majority of the vehicle population is found in the range of 3500 – 5500 kg Thus, an average sized front end loader is about equivalent to a truck by means of gross mass.

However, the full weight of the vehicle is carried only by two axles. This means if the suspensions are provided it should be robust enough to sustain the vehicle axle loads, which are higher than those of a road vehicle of comparable weight. The vehicle wheelbase is relatively short, which especially affects the pitching dynamics. Also, the large vehicle mass and off-road usage means that specialized tyres are used, which may have different characteristics than passenger car tyre.

Dynamic mass distribution:

The very complex and critical concept in vehicle stability and handling is dependent on vehicle mass distribution and speed. In the front end loader vehicle the mass distribution varies at time to time. This is because of the movement of loader bucket up and down , the front axle mass gets changed due to the change in length of hydraulic cylinders (boom cylinders).The moment created is increased or reduce based on the length of the arm front axle mass increases and reduces.

This change in mass changes the location of CG point front to rear. Thus when the CG point moves forward 1/3rd of overall vehicle length the vehicle loses the stability and tilts towards front this very likely to happen in the vehicle without proper counter weigh. So counter weight are added to the rear axles for maintaining stability at various positions.

Counter weight:

Counterweight is an equivalent counterbalancing weight that balances a load. Counterweights are often used in traction lifts, cranes. In these applications, the expected load multiplied by the distance that load will be spaced from the central support (called the "tipping point") must be equal to the counterweight's mass times its distance from the tipping point in order to prevent over-balancing either side. This distance times mass is called the load moment. The various points of loader bucket are shown in the fig 2.

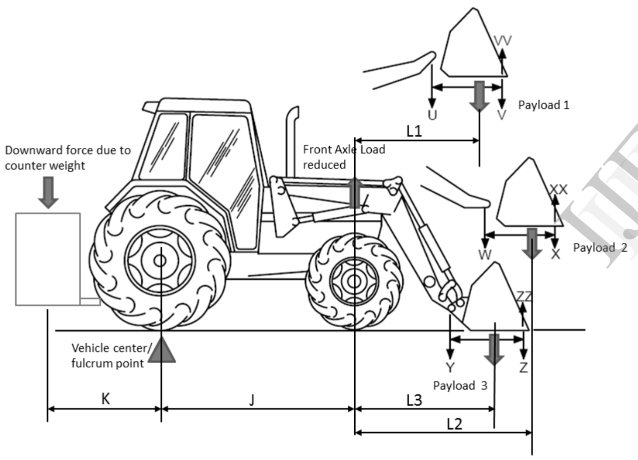
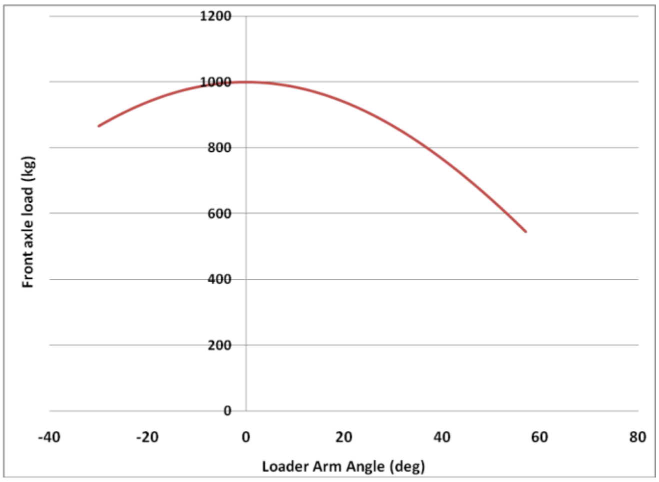


Figure 2

Calculating counter mass based on reaction at rear axle:

The loading and support points are taken from the above fig 2 and loads and reactions are calculated. The graph 1 shows the reaction at rear axle due to various angle of bucket arm with constant bucket load.



Graph 1

Counter weight calculation:

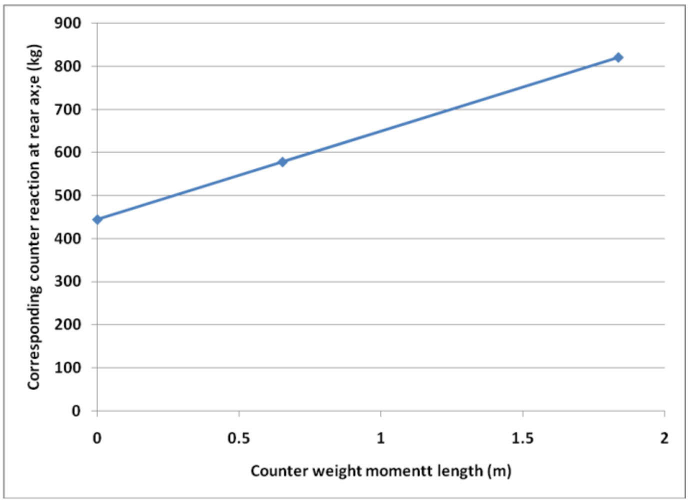
The counter weights for the various axle reactions are calculated with mass balancing equation and the results are tabulated in table 1

Bucket Position	Arm angle (deg)	Counter weight (kg)
Fully up	57	444.10
Horizontal	0	820.51
Fully down	-30	577.85

Table 1

Optimization of counter weight:

As the results of reaction calculated are varies from 440.10 kg to 820.51 kg. Now the counter weight is made constant and as minimum as possible for reducing the vehicle mass. So the counter weight is fixed to 400kg and the moment arm mechanism is fixed to the vehicle for achieving the moment with this fixed counter weight.



Graph 2

Moment Arm Mechanism:

The moment arm mechanism is a system that can articulate in radial by which the moment arm over hang distances changes. From the above analysis the mass balancing can be done by changing the moment length of the arm. The arm is pivoted to the center line of tractor and one end is fixed with fixed mass and the other side is coupled to a hydraulic ram, which moves forward and backward with respect to the angle of boom cylinder. This movement of ram will change the angle of moment arm and thus varying the effective moment length.

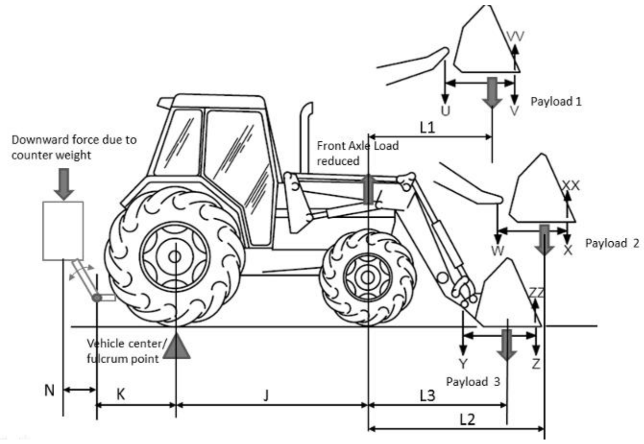
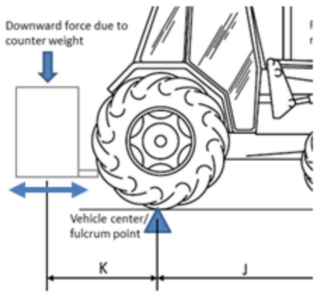


Figure 3

Sliding Arm Mechanism:

The same purpose of moment length change can also be done by moving the mass linearly forth and back .this mechanism has and sliding rail arrangement with rotating roller bearings. And mass is connected to the hydraulic ram which pushes and pulls the mass on the rails. Thus change is position of mass on the rail will change the moment length and change in mass is obtained



CONCLUSION:

The counter weight optimization can be made by swing fixed mass and tilting moment arm mechanism and sliding the mass by sliding arm mechanism and the mass balancing is done with the advantage of reduced mass, which results in better balancing and increased vehicle performance.

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