

Design and Analysis of Lifting Pusher Drop Axle for Heavy Commercial Vehicle

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ABSTRACT

Lifting axles are auxiliary axles that provide increased load carrying capacity in heavy commercial vehicles. Lift axle gives better fuel efficiency as well as it reduces the operational costs by means of increasing the loading carrying capacity. These axles are raised when the vehicle is in unloaded condition, thus increasing the traction on remaining wheels and reducing the tire wear which in turn lower down the maintenance cost of the vehicle. Lifting height and force requires to lift the whole mechanism and are two main considerable factors to design the lifting axle mechanism. Although in India currently, the use of lift mechanism of single tire with continuous axle is more common. But in the case of pusher axle, continuous axle is unable to lift more after certain height because of the draft angle of the propeller shaft, and single tire axle which has less load carrying capacity up to 6T (Tons). Multi-axle vehicles have 'pusher' axle that is present in front of the drive tandem axle, which gives additional load carrying capacity for such vehicles. Installing a lifting mechanism in the pusher axle with dual tire and centralized drop axle instead of the continuous axle with using air spring bellows can improve the lifting height without affecting the draft angle of the propeller shaft during the lifting time. Kinematics of lifting mechanism is designed in a way to decrease the lifting force with increase in load carrying capacity of the axle and decrease in packaging value. Dual tire causes less reaction between road and tire due to which tire wear will be reduced. This paper is about to study the whole kinematics; analytical design and to analyze lifting mechanism having 10T dual tire drop axle.

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INTRODUCTION

The axle is a hollow non-rotating shaft which supports the weight of the vehicle over the rotating wheel shaft and allows the rotational motion relative to the vehicle. It is the only part of vehicle which bears maximum load of the vehicle.

Instead of front axle and drive axle there are two more axles namely pusher and tag axle which are used in heavy commercial vehicles such as Beverages truck, Oil tank etc. The axle which is situated at the front of the driven axle is called 'Pusher' axle and back side axle is called 'Tag' axle which is also known as dead axle as shown in [Figure 1](#).

Number of axles in any particular vehicle depends on the payload of the vehicle. To reduce the reaction force impacted by the loaded vehicle to the ground surface, it is necessary to spread the allowable weight to all the axles. Hence the proper spacing between the axles is also important to consider. Number and spacing of axles can be determined by Bridge's law [1].

Vehicle's loading capacity can be increased by adding an extra compatible axle (which can bear that extra load) on the existing vehicle. On loading condition, that extra axle will be helpful but at unloading condition this type of system will be of no use, because due to extra axle, vehicle's self-weight will increase due to which load on engine will also increase which affects the fuel efficiency. More number of axles also increases the turning path of the vehicle. [2].

To overcome the foresaid troubles, lifting axle is the best arrangement which is used by many of trucks manufacturing companies. At un-laden condition, this extra axle will lift up in the air and under load on situation this axle will act as working axle. Lifting axle mechanism can be used either in pusher axle, tag axle or second front axle (FA II) [3].

Up to now in India only 6T pusher lift axle has been used. This paper is focusing on the design and development of the dual tire pusher lift axle with high load capacity of the axle i.e. 10T.

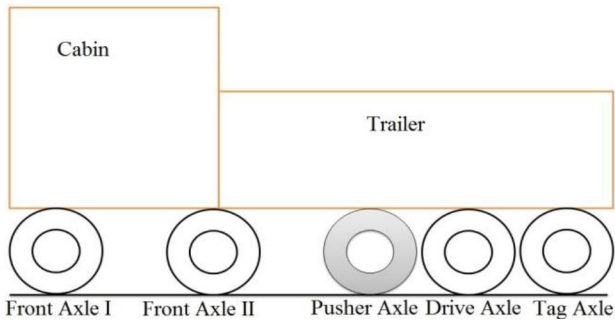


Figure 1. Truck with normal axes

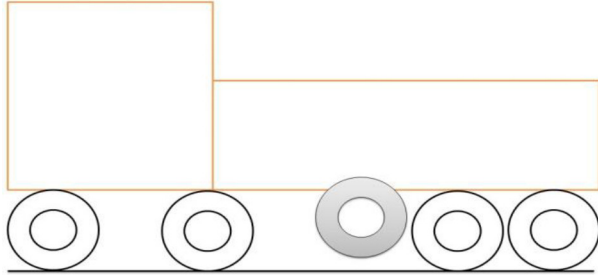


Figure 2. Truck with lifting pusher axle

Parts Description

The lifting axle arrangement is a separate part of the vehicle. It is also use as retrofit part.

There are so many parts having unique characteristics which are used in lift axle. Figure 3, detailed all the parts of lift axle as mentioned [4].

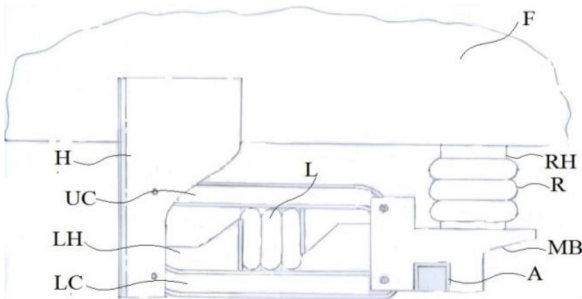


Figure 3. Non-Steer Lift Axle mechanism

Figure 3, 'A' represents the axle on which all the other parts are mounted. On the axle, there is mounting bracket 'MB' is fastened on which rider air bellow 'R' is mounted which helps the axle to move up and down. It is operated by the compressed air. Rider air bellow can work as a spring and can also act like a kind of shock absorber. There is rider air bellow bracket 'RH' which is connecting medium of frame 'F' and rider air bellow. Up to this configuration, used parts are responsible for the vertical unidirectional motion of the axle.

To apply the lifting force to the axle, another set of parts are used. Upper 'UC' and lower control arm 'LC' are used to connect the whole mechanism to the axle. One end of both control arms is directly hinged to the lower mounting bracket 'MB'. Another end of the control arms is hinged to the hanger bracket 'H'. The hanger

bracket is fastened with frame. Another mounting bracket 'LH' is welded on the upper and lower control arms, to mount the lift air bellow 'L'. Lift air bellow is also operated by the compressed air.

Principle of Lifting Axle

The principle of the lifting axle mechanism is purely based on the solid mechanics. Weight of the whole axle assembly with tires and brake chambers is huge. To lift the axle, it is required to apply that much force which can counteract with the axle capacity. This counteract force is called as lifting force. The whole system is based on different linkages. Benefit of the linkages is that less force will require to lift the axle than the actual axle's capacity. The reaction forces generated by the air bellows to lift the axle are transferred from one link to another link. That reaction force generates the moment at the joint of the linkages which causes the rotational motion. Degree of freedom for whole system is restricted due to which the rotational motion can rotate the whole system only in one direction. Linkages convert the applied lateral lifting force to the longitudinal motion of the axle which helps to pull up or push down the axle as per requirement.

Working Mechanism of the Lift Axle

The whole mechanism is operated by the both rider and lift air bellows. Both lifting and rebound condition of the axle depends on the combination and accordance of the compressed air inside both the bellows [5].

Lifting Condition

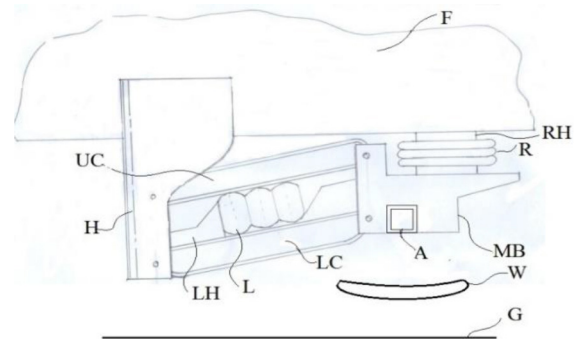


Figure 4. Lifting axle mechanism at lifted condition

To lift up the axle, allow the flow of compressed air inside the lift air bellow till it expands up to its maximum permissible elongation and at the same time released the all air from inside the rider air bellow. When the lift air bellow is expanded, it applies the opposite reaction force to their both mounting bracket. This reaction force transfers to the control arms as a moment because control arms are hinged on both of their ends. The reaction force acted on the mounting bracket tries to move the control arms but because of hinging ends, control arms are started to rotate with respect to their hanger bracket side hinged ends and moment is acted on all hinged ends of the control arms. As simultaneously air inside the rider air bellow is released so it starts to compressed and try to gain its original state. As rider air bellow connected to the axle so when it starts compresses then it pulls the axle

