

AN ERGONOMIC STUDY OF BACKHOE LOADER BY MAKING IT DIFFERENTIAL DRIVE

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The Abstract

This paper is written out of a concern. We noticed that if we make Backhoe loader differential drive, remote control we can increase its productivity and driver can work without being vulnerable while working over uneven terrain, places such as landslide and earthquake affected region. We were inspired by same steering mechanism which is being used in tanks used by army. In this model driver does not have to sit in cabin instead he can operate it from safe distance. We performed some test on a prototype of backhoe loader performing differential drive mechanism and result were positive. This research paper helps in research into the zero accident vision.

This research work comes under category ERGONOMICS: study of man and machine relationship.

Keywords- Mechanical, Megatronics, Ergonomics, Vehicle Safety

I. INTRODUCTION

As we all know the person who works on backhoe loader is always in the state of vulnerability, when he works on uneven terrain such as, earthquake affected area, and landslide affected area and so on. So if we can make this machine to work from a safe distance i.e. person will operate it from a safer distance instead of working while sitting inside the cabin. He can make this machine to work, while standing at a safer place, because sometimes when backhoe loader works at these places due to accidents we lost human life, so our problem is to deploy differential drive mechanism¹ over conventional steering mechanism.

The interesting part of this model is we do not have to operate it on a site moreover we can operate it from safe distance or place.

II. DIFFERENTIAL

In automobiles and other wheeled vehicles, a differential allows the driving road wheels to rotate at different speeds. This is necessary when the vehicle turns, making the wheel that is travelling around the outside of the turning curve roll farther and faster than the other. The engine is connected to the shaft rotating at angular velocity. The driving wheels are connected to the other two shafts, If the engine is running at a constant speed, the rotational speed of each driving wheel can vary, but the sum (or average) of the two wheels' speeds cannot change. An increase in the speed of one wheel must be balanced by an equal decrease in the speed of the other.

III. SOURCE OF POWER.

The source of power is generally from the engine. It is then transmitted to differential and from there to wheels. But in this model as it is a PROTOTYPE we have used a MOTOR mechanism for getting required force i.e. TORQUE. Each wheel has its own motor.

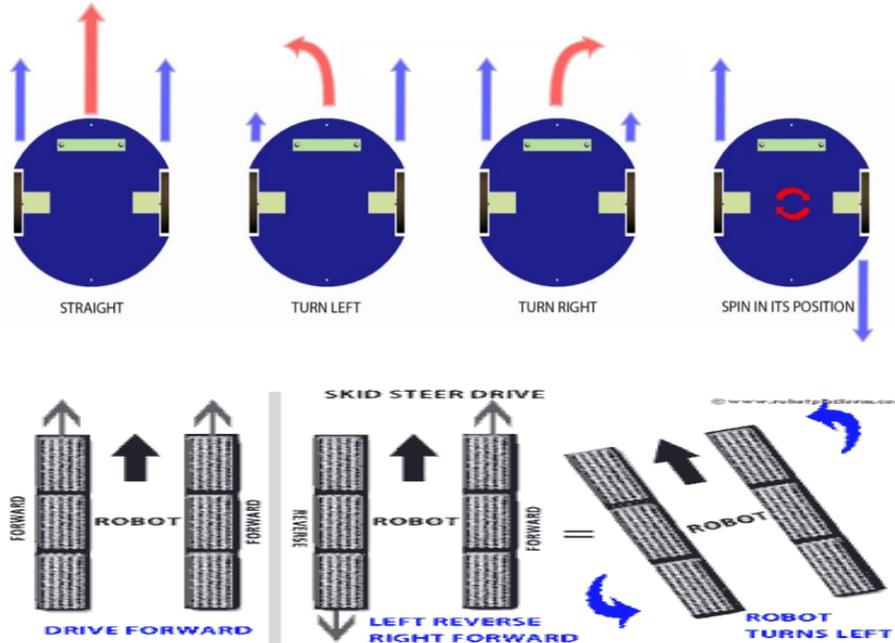
The motor which is used here is D.C motor.

IV. DIFFERENTIAL DRIVE MECHANISM & OBSERVATIONS

This project is based on demonstrating or deploying conventional Backhoe loader, normal steering system to **differential drive steering system**. In this type there is same power on set of wheels of Front & Rear of left side and vice-versa. In this mechanism *we do not have to turn Steering for turning* our Backhoe loader; we will just stop the power in any one set of wheel and allow the power in other set of wheel, Thus resulting that the stationary set of wheel will become the axis of turning and our machine will tend to turn in that particular direction. For e.g. If we have to turn our Backhoe loader towards right we will stop power in right wheel and allow power in left. It will be observed that the right set of wheels becomes the axis of turning and the vehicle turns right without turning the steering towards right.

¹ From Wikipedia

Another observation was **FOR MINIMIZING THE TURNING RADIUS**. The idea is to provide power in both the set of the wheel but in opposite direction i.e., if right set of wheel is moving forward, left set is moving backward it is observed that the turning axis is now shifted to centre of line joining the set of right and left wheels now Backhoe loader will turn with very short turning radius or we can say it will turn on the same point where it is in stationery position.



For e.g. if we have to turn the Backhoe loader towards right we will provide power in such a manner that in right set of wheels power is applied in backward direction and in left set of wheels power is applied in forward direction, resulting in shifting of the turning axis in centre and the Backhoe loader will turn towards right on same point without travelling extra distance.

V. DEPLOYMENT OF CONCEPT IN A BACKHOE LOADER

AUTO Limited Slip Differential (LSD) or BREAK ACTIVATED LSD DIFFERENTIAL

They work on basic principle of open differential¹ but electronic operated which result when one wheel loses its traction the break are automatically activated to that side wheel resulting in providing more resistance to that wheel which result in transferring most of the power to other wheel.

In this type breaks are selectively applied to those wheels which have least traction & power transfer to least resistance path. Hence will take out vehicle if it struck somewhere in low traction area.

I've tried to use above concept of AUTO LSD to make our vehicle differential drive.

Now, we provide two differential one for front and one for rear then we provide power by engine & it will divide it to wheel. As above we have understand how to steer the vehicle i.e. differential drive mechanism. If we have to turn our vehicle to the left we will activate LSD of right set of wheel i.e. (both FRONT & REAR) which will result in the transfer of whole power to these set of wheel because of more traction & as AUTO LSD work this way, hence our left side will be axis of turning & our vehicle will steer towards left without using steering for turning.

VI. MOVEMENT OF BACKHOE LOADER'S CLAW.

The efficiency or performance of Backhoe loader depends upon the design and it's Degree of Freedom (DOF). DOF implies that at how much extend & in how many direction a particular object can move. ***In our project this claw has 2 DOF***². Up and down perpendicular to the chassis of Backhoe loader and roll about its axis. It is used to dig earth, lift heavy loads etc.

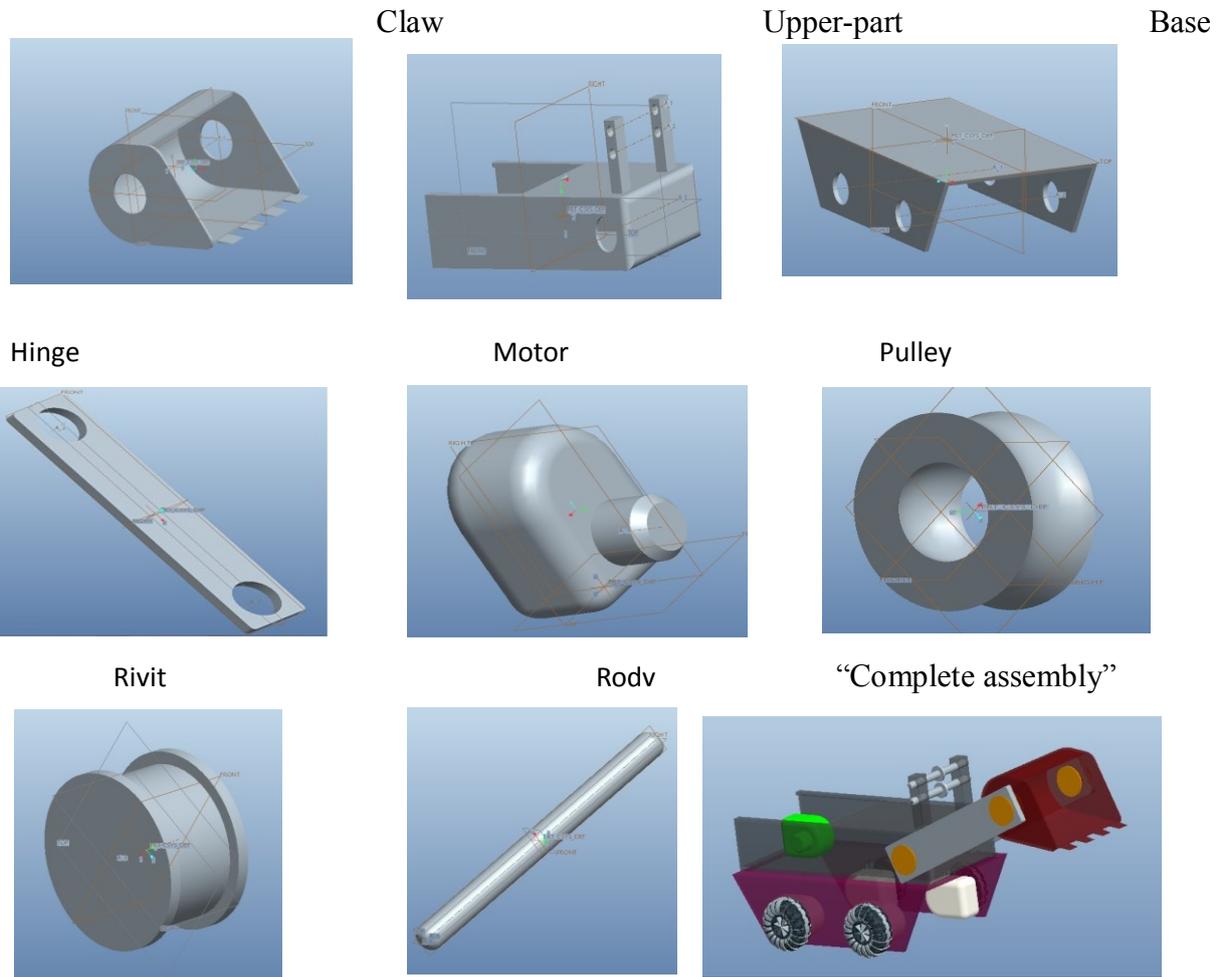
NOTE: Here we have used pulley mechanism to lift claw instead of hydraulic mechanism. But we can use any of the method.

² Degrees of Freedom – Source Internet

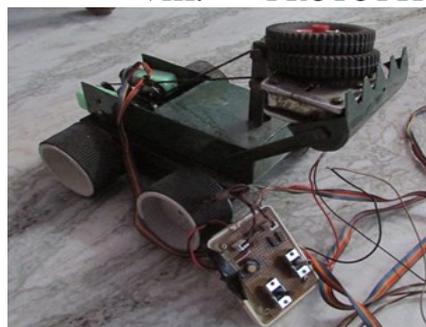
VII. PERFORMANCE EXPERIMENTS

This model has been developed in *“pro-engineering software”*.

Parts



VIII. “PROTOTYPE”



IX. EXPERIMENTAL ANALYSIS ON PROTOTYPE

Dimension of backhoe loader:

Height: 9 cm

Length : 19 cm (without hoe)

Width: 10 cm

Length: 30 cm (with hoe)

Hoe dimensions

Depth: 4 cm

Length : 10 cm

Width: 5 cm

Power given to each wheel

Voltage supply: 12

RPM of each wheel: 70 rpm

Torque on each wheel: 0.164 N-M

Maximum Inclination survived

For this we have used formula: $\tan \theta = \text{perpendicular} / \text{Base}$

Inclination angle $\theta = 23.61^\circ$

Turning Radius

One side power \rightarrow 40 cm (diameter) / 20 cm (Radius)

Reversed power on both set of wheels \rightarrow 30 cm (diameter) / 15 cm (Radius)



Observation shows that by making it differential drive we can reduce its turning radius as compared to conventional steering mechanism and this helps in better controlling and operating the backhoe loader. Hence ergonomics study confirms that by adopting this type of mechanism in a backhoe loader, we can significantly reduce the chances of an accident while the operator is performing an operation.

X. Conclusion

“Advantages of Differential drive Backhoe loader”

- More control: differentials offer more control when there are rounded corners or other situations in which the Backhoe loader may be slide.
- Safety: Due to the increased control that limited slip differentials provide, safety is increased exponentially. When turning around a corner in wet or slippery conditions,
- Power efficient: It also offers a greater amount of traction, which increases the speed and performance of the vehicle.

XI. VISION BEHIND THIS PAPER

It has always been an ambition within the ergonomic profession to ensure that design or redesign of Production systems consider both productivity and employee wellbeing. Main aim of working over this project is having concern about human life which is being lost when a human work over a machine at areas of land slide and other natural calamities.

Like, if a person is working on an area of landslide, while doing his work, if landslide occurs again it will cause threat to his life. So making it remote control and differential drive we can control and operate it through a safe area so if some miss-happening occurs we would not lose human life.

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