ISSN 2250-3153

# Development, Testing and Monitoring of the Movement of Three Directional Tipper Mechanism

**Sanjaykumar A. Borikar, Hemant V. Karkade, Pramod G. Pokley**

Department of Mechanical Engineering, Kavikulguru Institute of Technology & Science, Ramtek-441106, India

***Abstract-*** Conventional tipper mechanism an unload materials only at the backside of the tipper using hydraulically operated boom which may cause the problems of road blockage in the limited space area. The prototype model of three direction movement tipper overcomes the problem of unloading the vehicle on side way by using BOOM (D.C. Motor operated). By using Boom the material can be unloaded in all three directions as per requirement. The prototype is developed and tested foe its movement in all three possible direction to unload the materials in the tipper trolley and monitor the inclinations for its gradualism (linearity). The results of inclination of the tipper in all three directions are obtained with respect to time period with material and without material as $22.80^0$ and $23.24^0$ for 100 seconds of operation of tipper respectively.

***Index Terms***- Tipper, BOOM, D.C. Motor, hinge joint, hydraulic cylinders, control circuit

## I. INTRODUCTION

Automobile is made up of two words, i.e. "Auto" and "Mobile" 'Auto' is self-propelled and 'Mobile' is vehicles and as such the meaning of these two wards is self-propelled vehicle i.e. all such vehicles which run with their own power are called automobiles. Vehicle is divided into two parts, (1) Chassis (2) Body. Vehicle without body is known as chassis. [1]

An automobile industry is growing sector in India. Automobile sector includes variety of vehicles light duty vehicles, medium duty vehicles and heavy duty vehicles. Heavy duty vehicles include bus, tractors, trucks etc. [1]

The tipper truck is important machinery in mining, construction sector to unload the material on site with minimum help of workers. The purpose of tipper mechanism is to unload the trolley of vehicle without or with little assistant of human. It provides the means for unloading the trolley with minimum time period with no effort.

A tipper truck is nothing but whose material can be emptied without handling the material. The front end of platform can be hydraulically raised so that the load is discharged by gravity which is known as "tipper mechanism". Tippers which are in existence to facilitate unloading of material are in only one direction. But it requires a lot of space and often results in blocking of the road. In order to resolve these problems we are providing the modification in existing system. We are providing the sideways movements of the trolley which could be very useful where there is a shortage of space. This mechanism prevents blocking of the road which saves the time and enhances the productivity. [9]

## II. HOW TYPICAL TIPPER WORKS

Tipping mechanism works basically on the followings:

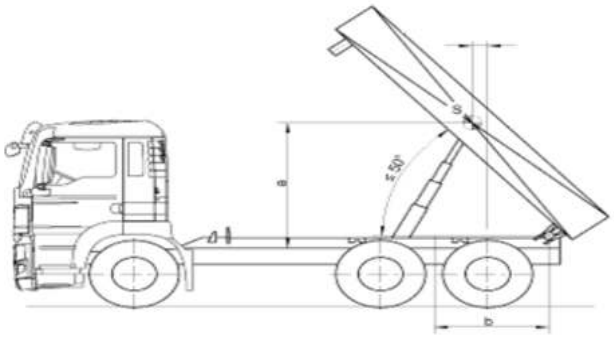

Fig. 1 Line diagram **o**f conventional tipper truck

1) Hydraulic cylinder

A hydraulic cylinder is placed below the body of truck longitudinally at one end of the truck; the piston end of the hydraulic cylinder is connected by the means of a pivot joint to the chassis of truck as well as with the chassis.

In the forward stroke of the cylinder it pushes the truck body upward thus gives necessary lift for tipping. So, in forward stroke of the cylinder truck gets unloaded. In the return stroke of the cylinder the body of the truck comes to its original position.

2) Hinge Joint

The other bottom end of the body of the truck is connected by a hinged joint with the chassis. So, when the hydraulic cylinder pushes the body in its forward stroke the whole body gets tilted about the axis of the hinged joint and the material gets unloaded and by the return stroke of the hydraulic cylinder body comes and seat to its original position with respect to the hinged axis. But in this types of tipper can unload materials only at the backside of the tipper. 3-directional tipper can overcome this problem; it can unload material in all three sides. [7]

## III. COMPONENTS OF THREE DIRECTIONAL MOVEMENT TIPPER MECHANISM

*1) Chassis*

Vehicle without body is known as chassis. Chassis frame are made of steel section so that they are strong enough to withstand the load and also light in weight to reduce dead weight on the vehicle. The functions are as follows:

1) To support the load of body, engine, gear box and radiator etc.
2) To carry load of material carried in the body.

3) To withstand stresses caused due to load. [1]

*2) FRAME*

In this work two frames which are placed above the chassis, i.e. upper frame and middle frame are used. The frames used are made of mild steel. A clearance gap of 32 mm is present in between the frame. Upper frame is placed on the four supporting hinges and trolley is fitted on the upper frame.

There are three square shape supporting plates are used. One plate is attached to the chassis on front side and other two plates are attached on both side middle frame. All the booms take the support of the supporting plate and will lift the trolley on the upper side. Two booms are positioned at the middle part of the upper frame from both the sides and one boom is attached from the front side to middle frame.

In this way frames plays an important role in tilting the tipper on all the three sides. Hence we have used two additional frames for giving three way movement of the trolley.

*3) Boom (D.C. Motor operated)*

The boom used in this work is motor operated screw boom. The main components of boom are D.C. Motor, Lead screw, Hexagonal nut, supporting rod, rectangular cover and ball bearing. The main function of boom is to lift and tilt the trolley with load.

The D.C. Motor used in the boom is connected on the upper end of lead screw and ball bearing is connected to lower end so that lead screw rotates smoothly. A nut is connected with and over lead screw. Two supporting rod (Ni-alloy steel) are welded on two side of nut like one in front of other. As motor rotate lead screw also rotate with help of bearing. Nut mounted on lead screw move up or down according to rotation direction with help of helical screw thread. So that, supporting rod move down. One of supporting rod strike the plate and another rod will use for lifting the trolley.

As it is prototype model, to show mechanism, here used D.C. Motor operated boom for more torque. But, in actual manufacturing of truck, instead of motor operated boom should used hydraulic boom for unloading the more tones of material smoothly.

*4) LEAD SCREW*

A lead screw also known as a power screw or translation screw is a screw designed to translate turning motion into linear motion. Common applications are machine slides (such as in machine tools), vices, presses, and jacks. Lead screws are manufactured in the same way as other thread forms. A lead screw can be used in conjunction with split nut. [2]

*5) Ball-Bearing*

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the moving parts of the bearing. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls. Usually one of the races is held fixed. As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were rotating on each other. [1, 3]

Figure 1: Ball Bearing

Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races. Compared to other rolling-element bearings, the ball bearing is the least expensive, primarily because of the low cost of producing the balls used in the bearing.

*6) Transformer*

It is an electrical instrument, which is used to step up or to step down supply voltage. Mutually induced emf is the principle of the working transformer. Transformer is a device that increase or decrease the voltage of alternating current. Transformer provides a simple, inexpensive way to change such voltage. They enable electric power companies to transmit alternating current easily and efficiently. They also ensure the proper voltage for the circuit of home appliances and other electric equipment. Transformer consists of two coils of insulated wire. One coil, known as the primary winding, is connected to the sources of the voltage that is to be changed. This voltage is the input voltage of the transformer. The other coil, called the secondary winding, supplies the output voltage to the desired circuit in most transformers; the primary and secondary windings are wound around a hollow core made of thin iron or steel sheets. Most cores have the shape of a ring or a square. The top two coils are not connected to each other. [5]

*7) Resistance*

The properly of substance which oppose the flow of electric current is called resistance. Resistance is a heat dissipating element used for either controlling the current in the circuit or developing a voltage drop across it. There are various types of resistance. This can be classified according to factor depending upon.

1. Material used for fabricating a resistance.
2. Matt age and physical size.
3. Intended application.
4. Ambient temperature rating and
5. Cost

*8) Capacitor*

It is a device, which has the circuit and also blocks the passage of direct current through it. Capacitor consist of two conducting plates separated by an insulating medium all dielectric. The dielectric could be air, mica, ceramic, plastic etc. designee of

capacitor is connected with the relation of the proper dielectric material for particular type of application. It is the amount of charge required to create a unit potential different between two plates.

Figure 2: Capacitor

*9) Battery*

Lead-acid batteries, invented in 1859 by French physicist Gaston Plante, are the oldest type of rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, their ability to supply high surge currents means that the cells maintain a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by automobile starter motors.

In this present work motor operated screw boom is used for lifting the trolley. Here uses two batteries which are connected in series with each other. Each battery is of 6V. In this way by connecting two batteries in series developed a potential of 12V for operating the 12V, 30 r.p.m D.C geared motor.


Figure 3: Battery

*10) D. C. Motor*

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. As you are well aware that opposite polarities attract, while like polarities (North and North, South and South) repel. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

Every DC motor has six basic parts - axle, rotor (a.k.a., armature), stator, commutator, field magnet(s), and brushes. In most common DC motors, the external magnetic field is produced by high-strength permanent magnets. The stator is the stationary part of the motor -this includes the motor casing, as well as two or more permanent magnet pole pieces. The rotor (together with the axle and attached commutator) rotates with respect to the stator. The rotor consists of windings (generally on a core), the windings being electrically connected to the commutator. The above diagram shows a common motor layout with the rotor inside the stator (field) magnets.


Figure 4: Exploded view of motor

*11) Toggle switch*

A toggle switch is a class of electrical switches that are manually actuated by a mechanical lever, handle, or rocking mechanism. Toggle switches are available in many different styles and sizes, and are used in countless applications. For e.g. the control of large amounts of electric current or mains voltages.


Figure 5: Six pin Toggle switch

The word "toggle" is a reference to a kind of mechanism or joint consisting of two arms, which are almost in line with each other, connected with an elbow-like pivot.

*12) Push on switch*

A push button switch is used to either close or open an electrical circuit depending on the application. Push button switches are used in various applications such as industrial equipment control handles, outdoor controls, mobile communication terminals, and medical equipment, and etc. Push button switches generally include a push button disposed within housing. The push button may be depressed to cause movement of the push button relative to the housing for directly or indirectly changing the state of an electrical contact to open or close the contact. Also included in a pushbutton switch may be an actuator, driver, or plunger of some type that is situated within a switch housing having at least two contacts in communication with an electrical circuit within which the switch is incorporated.


Figure 6: Push to on switch

## IV. MODIFICATION IN TIPPER MECHANISM

The three directional tippers can unload materials in all three sides. Internally to control the sides of tipping there needs to be required two more hydraulic booms instead of one boom. But in this present work by using motor operated screw boom instead of hydraulic boom. Also here require special types of hinge joints in this case.

Figure 7: Prototype model of Three-Directional tipper truck

When the front boom fitted on the smaller side of middle frame will activate then, the material will be removed on the backside of tipper.

When the central boom fitted on the bigger left hand side of middle frame will activate and then the material will be removed on the right hand side of tipper when observed from the front end. When the central boom fitted on the bigger right hand side of middle frame will be activated then, the material will be removed on the left hand side of tipper when observed from the front end. At a time only one movement is possible. In this way, the three way tipper mechanism will work. Automation of tipping will be possible by using a power pack with plc control or some similar kind of automation devices.

*1) Electrical circuit used in this work*

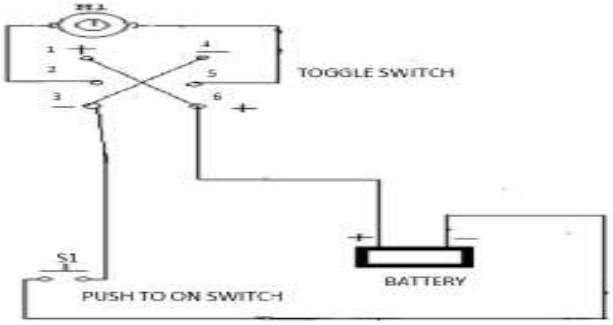


Figure 8: Circuit for single boom operation

The above diagram represents about control system used in activating the boom for tilting purpose. This construction consist of six pin toggle switch which are numbered as 1, 2, 3, 4, 5 and 6 as shown in figure,30 r.p.m., D.C. motor, push on switch and battery. Both poles of motor are connected to the middle pin 2 and 5 of a toggle switch.

As one move the toggle switch upper side the middle pins 2 and 5 will get internally connected to the upper pins 1 and 4. So, the left end of motor will get positive polarity and right end of will get negative polarity. As one press the push on switch the current will start flowing through the circuit and the entire circuit will be completed. And hence motor will start rotating.

When one move the toggle switch lower side the pins 2 and 5 as well as pins 3 and 6 will get internally connected and the polarity of motor will changed means left end of motor will have negative polarity and right end will have positive polarity hence due to change in polarity the motor will start rotating opposite direction.

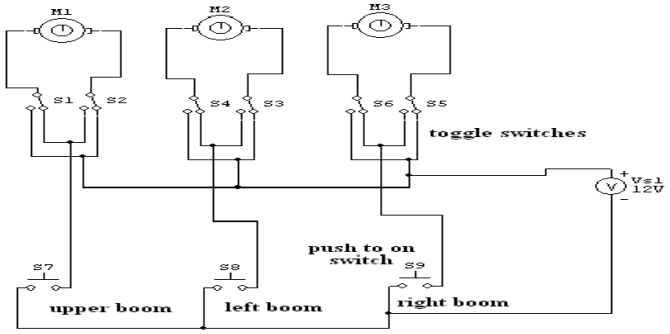


Figure 9: Circuit diagram for boom control

The above circuit consists of three motor, three toggle switch, three push on switch connecting wire and battery are as shown in Fig.10.

Both the end of motor are connected with the middle pins of a toggle switch and one end of toggle switch is connected to push on switch similarly same connection is done for other two motor. Hence all three motor are connected in series with battery. So, one can operate each boom individually according to requirement.

*2) Charger*

Charger consists of step-down transformer, full wave rectifier, capacitor and connecting wire. Transformer is having primary and secondary winding. Full wave rectifier consists of four p-n junction diode arranged in the form of a bridge. Generally the current supply used for domestic purpose is of 230 volt. When these high voltage alternating current pass through the step down transformer then it will reduced this high voltage current in to low voltage (12 volt).Now this current will pass through the full wave rectifier. The main function of full wave rectifier is to convert the whole of input waveform to one of constant polarity (positive or negative) as its output means it converts this alternating current (AC) to direct current (DC). As the direct current produced is having pulse type wave nature so, to convert this into linear form a capacitor is used which work as a filter in the circuit. In this way charger convert alternating current to direct current more effectively.

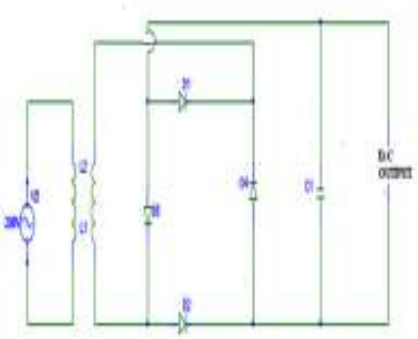

Figure 11: (A and B) Battery charger and Charger Circuit

## V. DESIGN AND SPECIFICATION OF DIFFERENT COMPONENTS

### *1) Design of Lead screw*

Assumptions
Outer diameter of lead screw =10mm
pitch = 2mm

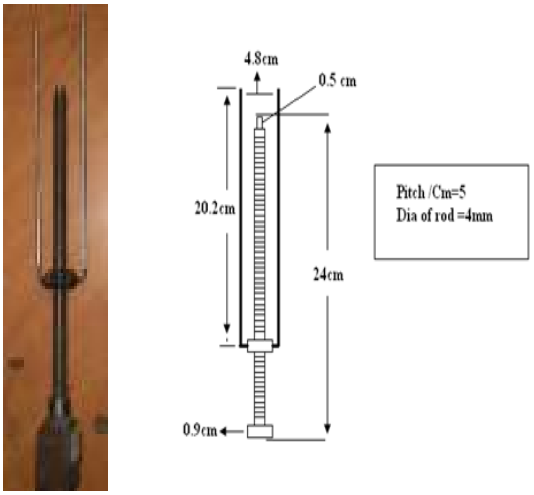


Figure 10: Image and Schematic of Lead Screw

## Specification:

Outer Diameter (do) = 10 mm
Pitch (P) = 2 mm
Mean Diameter :- (do – p/2) = 9 mm
Assume μ = 0.09. [4]
Angle of friction at screw (θ) = $\tan^{-1}$ (μ)
$\tan^{-1}$ (0.09) = 5.14
Helix Angle (α) = $\tan^{-}$1 (l/πdm) = 4.04. [4]
l = p (Pitch)
l = 2 mm (single start)
Calculation of Motor power
Power (P) = 2πNT/60
Where N = 30 rpm
Total torque (T) = $T_1$+Tc
Where $T_1$ = Lifting torque
Tc = Torque due to collar friction (Neglect)
T1 = (W dm/2) tan (θ+α). [4]
Where, W =Weight
W = m * g
= 142.68 N-mm
Power (P) = 0.448 watt = 0.0006Hp

Checking the strength of the column by using buckling equation for long columns

Since (L/K) = 113 > 90

Where, L= 226 mm
K = (dc/4) = 2 mm
$d_c$ = do – p = 8 mm
Which is greater than 90.
Hence Euler's formula will be Valid.
Calculation of Fcr by Euler's formula
Selecting material SAE 1040. [4]
Syt = 350 Mpa,
E= 203 x $10^3$
Fcr= (nπ²EA) / (L/K) ². [4]
Where, A = (π/4) x 00000dc²
dc = do – p = 8 mm
A = 50.24 mm²
K= radius of gyration
Column constant (n) = 0.25. [4]
Now,
Fcr = 1970.73 N
For the induced load by the wagon considering F.O.S = 4.
W = F.O.S x weight of wagon = 4 x 20 x 9.81 = 784.8 N

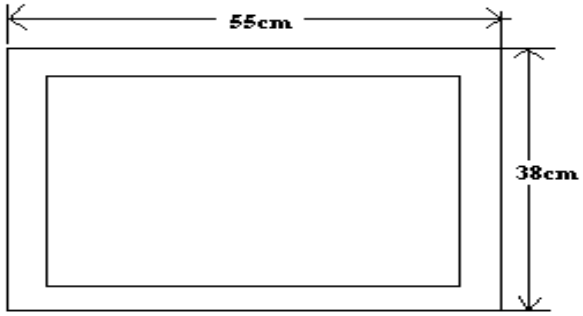


Figure 11: Frame

But Fcr = 1970.73 N is greater than 784.8 N.
Hence screw is safe in buckling
Height of Nut
Height of Nut = No of thread x Pitch
Where, n = Number of thread engaged with Nut.
Bearing pressure (Pb) = W/ [(π/4)x(do² - dc² ) x n]. [4]
Assume Pb = 10 Mpa [4]; (safe bearing pressure)
= [784.8/ (π/4(0.01*0.01 – 0.008* 0.008)*n)] *10^7
= 2.77
= 3
Height of nut = 3*2
= 6 mm.

### *2) Chassis*

For the design of chassis and frame, used material is mild steel. The dimensions of cross member 1*1 inch.

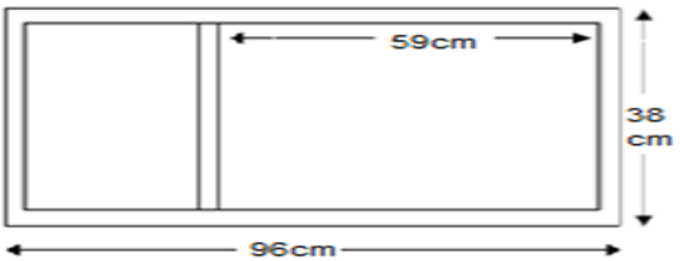


Figure 12: Line diagram of chassis

- Length of the chassis = 96cm.
- Width of the chassis =38cm.

*3) Middle frame and Upper frame*

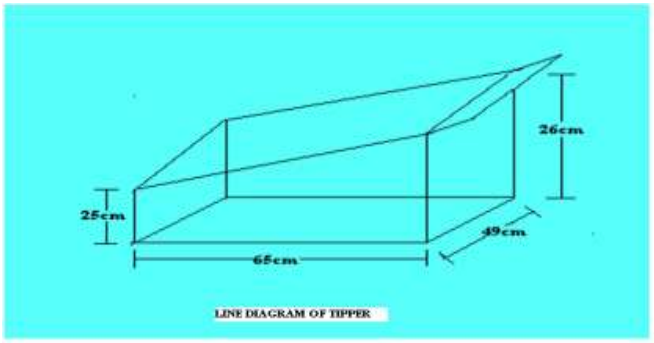


Figure 13: Line diagram of trolley

Material used for frame is mild steel.
Length of middle frame = 65 cm.
Length of upper frame =55 cm
Width of middle and upper frame = 38cm.

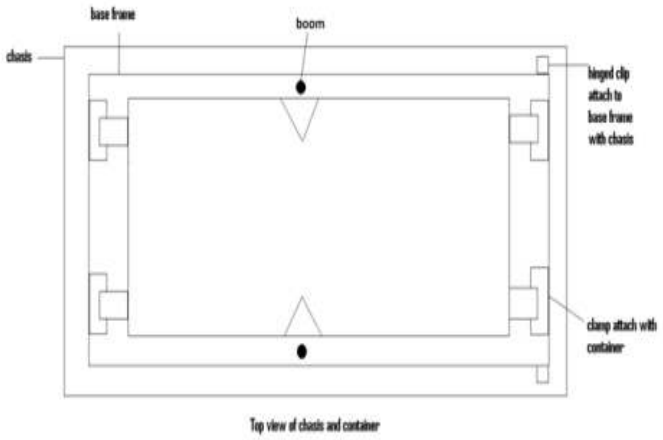


Figure 14: Top view of chassis and container

*4) Dimensions & carrying capacity of tipper from standard data*

By using the standard specification from Tata Trucks >>S K 1613 (Tipper) Tipper Body Options - Scoop- 4.5 to 6 $m^3$ and Box - 6 to 8 $m^3$.
Here in this work scoop type tipper is used and the volume of scoop type tipper used in Tata trucks is in the range of 4.5 to 6 $m^3$.
Volume of tipper used in the Tata trucks is taken as = $5m^3$.
For this work it is assumed that the prototype is 61 times smaller than standard dimension of Tata trucks.
Assume volume of our tipper = 1/61(the volume of Tata tipper)
the volume of our truck = (5000000/61) $cm^3$.
= 8085 $cm^3$.
Now, assume the length & width of our tipper is 65cm & 50cm respectively.
So from this the height tipper can be easily calculated.
Height of our tipper = 80850/ (65*50)
=25 cm.
Hence on the basis above calculation one can easily determine the dimensions of prototype tipper.

## VI. TESTING AND RESULTS

For confirming the stability of the tipper mechanism the movement of tipper is tested and balancing of the trolley is checked. In this work various reading are taken. Table 1, 2 3, 4 and Fig.17, 18, 19, 20 represents the variation in angle with time when unloading of tipper on back side and sideways with and without material.

Table-1 Variation of angle with time when unloaded on back side with material

| Sr. No | Time(Sec | Angle (Degree) |
|---|---|---|
| 1 | 10 | 1.76 |
| 2 | 20 | 2.81 |
| 3 | 30 | 3.6 |
| 4 | 40 | 4.92 |
| 5 | 50 | 5.88 |
| 6 | 60 | 6.75 |
| 7 | 70 | 7.66 |
| 8 | 80 | 8.74 |
| 9 | 90 | 9.94 |
| 10 | 100 | 11.3 |

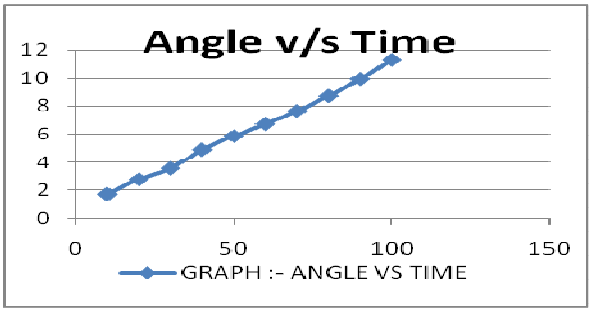


Figure 15: Variation of angle with time when unloaded on back side with material.

Table 1 and fig.17 represents the inclination of the tipper on back side while unloading the material (500gm) from tipper trolley is gradual with variation of $0.9^0$ to $1^0$.

Table- 2 Variation of angle with time when tilted on back side without material

| Sr.No | Time(Sec) | Angle (Degree) |
|---|---|---|
| 1 | 10 | 2.02 |
| 2 | 20 | 3.08 |
| 3 | 30 | 3.98 |
| 4 | 40 | 5.27 |
| 5 | 50 | 6.14 |
| 6 | 60 | 7.88 |
| 7 | 70 | 9.17 |
| 8 | 80 | 10 |

| | | |
|---|---|---|
| 9 | 90 | 11.3 |
| 10 | 100 | 12.76 |

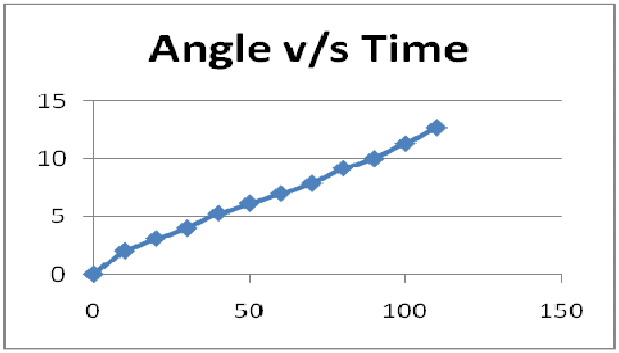


Figure 16: Variation in angle with time when tilted on back side without material.

Table 2 and fig.18 represents the inclination of the tipper on back side while unloading the tipper without from tipper trolley is not gradual but slightly damping with variation of $0.9^0$ to $1.2^0$.

Table-3 Variation of angle with time when unloaded by side way with material.

| Sr.No | Time(Sec) | Angle (Degree) |
|---|---|---|
| 1 | 10 | 4.93 |
| 2 | 20 | 5.11 |
| 3 | 30 | 7.65 |
| 4 | 40 | 9.56 |
| 5 | 50 | 10.84 |
| 6 | 60 | 14.43 |
| 7 | 70 | 15.85 |
| 8 | 80 | 19.12 |
| 9 | 90 | 21.26 |
| 10 | 100 | 22.8 |

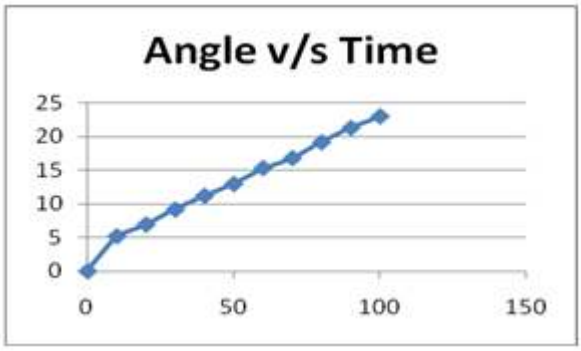


Figure 17: Variation of angle with time when unloaded by side way with material.

Table 3 and fig.19 represents the inclination of the tipper on side way while unloading the material (500gm) from tipper trolley is gradual with variation of $1.3^0$ to $2^0$.

Table- 4 Variation of angle with time when tilted by side way without material

| Sr.No | Time(Sec) | Angle (Degree) |
|---|---|---|
| 1 | 10 | 5.20 |
| 2 | 20 | 6.94 |
| 3 | 30 | 9.17 |
| 4 | 40 | 11.20 |
| 5 | 50 | 12.96 |
| 6 | 60 | 15.33 |
| 7 | 70 | 17.13 |
| 8 | 80 | 19.16 |
| 9 | 90 | 21.34 |
| 10 | 100 | 23.24 |

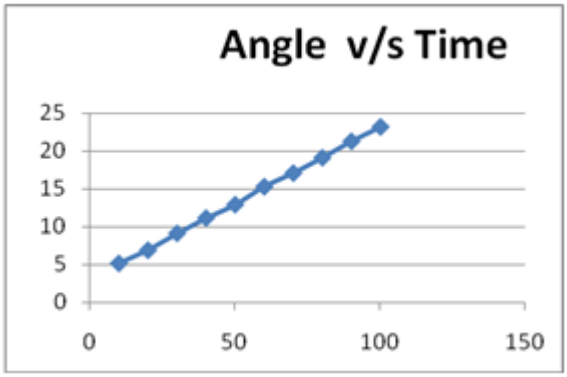


Figure 20: Variation of angle with time when tilted by side way without material.

Table 3 and fig.20 represents the inclination of the tipper on side way while unloading the tipper without from tipper trolley is gradual with variation of $1.3^0$ to $2^0$.

## VII. CONCLUSION

Three Directional tipper mechanisms is the modification of conventional tipper mechanism. The testing and monitoring of inclination confirmed the suitability and proper balancing of this mechanism. Hence with the help of this mechanism one can reduce the time of unloading the material in space constraint area. It prevents the blockage of road in places crossway movement of trucks in back sided tipper. In this present work the problem of unloading the material at the backside of the tipper is overcome by using BOOM (D.C. Motor operated). By using Boom the material can be unloaded in any three directions as required. In this paper the design and development of various components of the BOOM, assembly and finally the testing of the tipper mechanism is explained and the optimum results of inclination of tipper with respect to time, with material and without material as $22.80^0$ and $23.24^0$ in 100 seconds respectively. The D.C. operating BOOM can be replaced by hydraulic boom for heavy application.

## ACKNOWLEDGMENT

The author is thankful to Dr. Bhaskar Patel, Principal, KITS Ramtek for facilitating research in Automobile. The support and encouragement by Head and faculty of Department of Mechanical Engineering has been a source of inspiration

throughout. Special thanks are due to the Management of KITS for supporting this work and to the students who helped in developing the prototype. Mr. D. A. Borikar, Head, Department of Information Technology, deserves a special mention for valuable suggestions and proof reading of the manuscript.

## REFERENCES

[1] Nakara C.P., "Basic Automobile Engineering", (7th Edition), Dhanpat Rai Publishing company, New Delhi, 2005, pp 9-10, 13-16.

[2] Bhandari V.B., "Design of machine elements", (25th Reprint), Tata McGraw-Hill, New Delhi, 2006, pp 164-184.

[3] Rattan S.S., "Theory of machine", (21st Reprint), Tata McGraw-Hill, New Delhi, 2004, pp 385-387.

[4] Shiwalkar B.D., "Design data for machine elements", (3rd Edition), Denett & Co., Nagpur, 22nd June 2008, P.P.31, 39, 93, 94.

[5] Sasikala B. & Poornachandra C., "Electronic Device and Circuit", (2nd Edition), Scitech Publication Private Limited, India, 2003, pp 2.38, 2.39, 3.1-3.4.

[6] Kumar Manoj, "Electronic Component and Material", (1st Edition), Satya Prakashan, New Delhi, 2002, pp 115-118,167,168,220-222

[7] *www.brighthub.com/engineering/mechanical/topics/automobiles.aspx?PageIndex=6*

[8] www.fourwheeler.com/techarticles/trail/129_0707_thule_3_way_tipper_trailer/ index.html

[9] *www.tatamotors.com/fullforward_controlchasis/1518tipper truck/index.html*.

**First Author-** Sanjaykumar A. Borikar, Assistant Professor, Department of Mechanical Engineering, Kavikulguru Institute of Technology & Science, Ramtek-441106, e-mail: sanjayborikar@gamil.com, Mobile: +91 9423600469.

**Second Author-** Hemant B. karkade, Assistant Professor, Department of Mechanical Engineering, Kavikulguru Institute of Technology & Science, Ramtek-441106, e-mail: hemantkarkade@rediffmail.com, Mobile: +91 9860140785.

**Third Author-** Pramod G. Pokley, Assistant Professor, Department of Mechanical Engineering, Kavikulguru Institute of Technology & Science, Ramtek-441106, e-mail: pramod.pokley@yahoo.co.in, Mobile: +91-992168706.