Design and Development of 3-Way Dropping Dumper

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Abstract— ‘Modern 3 ways dropping dumper’ has been conceived by observing the difficulty in unloading the materials. The survey in this regards in several automobile garages, revealed the facts that mostly some difficult methods were adopted in unloading the materials from the trailer. This paper has mainly focused on above difficulty. Hence a prototype of suitable arrangement has been designed. The vehicles can be unloaded from the trailer in three axes without application of any impact force. The Direction control valve which activates the ram of the hydraulic cylinder which lifting the trailer cabin in require side. Further modifications and working limitations will put this work in the main league of use. This concept saves time & energy which leads to efficient working.

Keywords— Hydraulic Cylinder, Hinge Joint, Three Way Tipper Mechanism, Hydraulic System, D.C. Motor.

I. INTRODUCTION

A dumper is a vehicle designed for carrying bulk material, often on building sites. Dumpers are distinguished from dump trucks by configuration: a dumper is usually an open 4-wheeled vehicle with the load skip in front of the driver, while a dump truck has its cab in front of the load. The skip can tip to dump the load; this is where the name "dumper" comes from. They are normally diesel powered. A towing eye is fitted for secondary use as a site tractor. Dumpers with rubber tracks are used in special circumstances and are popular in some countries.

Early dumpers had a payload of about a ton and were 2-wheel drive, driving on the front axle and steered at the back wheels. The single cylinder diesel engine (sometimes made by Lister) was started by hand cranking.

The steering wheel turned the back wheels, not front. Having neither electrics nor hydraulics there was not much to go wrong. The skip was secured by a catch by the driver's feet. When the catch is released, the skip tips under the weight of its contents at pivot point below, and after being emptied is raised by hand.

Modern dumpers have payloads of up to 10000kg and usually steer by articulating at the middle of the chassis (pivot steering).

They have multi-cylinder diesel engines, some turbocharged, electric start and hydraulics for tipping and steering and are more expensive to make and operate. An A-frame known as a ROPS (Roll-Over Protection) frame may be fitted over the seat to protect the driver if the dumper rolls over. Some dumpers have FOPS (Falling Object Protection) as well. Lifting skips are available for discharging above ground level. In the 1990s dumpers with swivel skips, which could be rotated to tip sideways, became popular, especially for working in narrow sites such as road works. Dumpers are the most common cause of accidents involving construction plant.

A dumper is an integral part of any construction work and hence its role is important for completion of any constructional site. One of the problem are cited with dumper in the time and energy for setting the huge dumper in the proper direction to dump the material it in carrying and hence the need of the project work riser which is about 3 way dropping dumper which can dump the material in any direction except the rental one without moving the truck in any direction.

A dump truck (or, UK, dumper truck) is a truck used for transporting loose material (such as sand, gravel, or dirt) for construction. A typical dump truck is equipped with a hydraulically operated open-box bed hinged at the rear, the front of which can be lifted up to allow the contents to be deposited on the ground behind the truck at the site of delivery. In the UK and Australia the term applies to off-road construction plant only, and the road vehicle is known as a tipper, tipper lorry (UK) or tip truck (AU).

II. LITERATURE REVIEW

II-A Hydraulic Dump Bodies

Hydraulics was being incorporated into truck mounted dump bodies relatively early on, in which record shows one of the first hydraulic dump bodies was the Robertson Steam Wagon with a hydraulic hoist that received power from the truck’s engine or an independent steam engine[3]. Alley & McLellan of Glasgow developed another early hydraulic dump body in 1907 that was power-driven by steam.
II. Types of Dump Truck

1. **Standard Dump Truck**: Another kind of 8x4 dump truck: three rear axles (two powered one lift) [2]. A standard dump truck is a truck chassis with a dump body mounted to the frame. The bed is raised by a hydraulic ram mounted under the front of the dumper body between the frames, and the back of the bed is hinged at the back to the truck. The tailgate can be configured to swing on hinges or it can be configured in the "High Lift Tailgate" format wherein pneumatic rams lift the gate open and up above the dump body.

2. **Articulated Dump Truck**: An articulated dump truck, or "Yuke" in the construction world, has a hinge between the cab and the dump box, but is distinct from semi trailer trucks in that the cab is a permanent fixture, not a separable vehicle. Steering is accomplished via hydraulic rams that pivot the entire cab, other than rack and pinion steering on the front axle. This vehicle is highly adaptable to rough terrain. In line with its use in rough terrain, longer distances and overly flat surfaces tend to cause driveline troubles, and failures. Articulated trucks are often referred to as the modern scraper, in the sense that they carry a much higher maintenance burden than most trucks. See the first mass produced articulated dump truck (articulated hauler) [5].

3. **Transfer Dump Truck**: A transfer dump is a standard dump truck which pulls a separate trailer which can also be loaded with aggregate (gravel, sand, asphalt, klinkers, snow, wood chips, triple mix, etc.)[7] The second aggregate container, (B box) on the trailer, is powered by either an electric, pneumatic motor or hydraulic line. It rolls on small wheels, riding on rails from the trailer's frame, into the empty main dump (A) box. This maximizes payload capacity without sacrificing the maneuverability of the standard dump truck. Transfer dumps are typically seen in the western United States because of the peculiar weight restrictions on western highways. Another configuration is called a Triple Transfer Train, which consists of a B and C box. These are common on Nevada and Utah Highways but not in California. Depending on the axle arrangement, a Triple Transfer can haul up to 129,000 kilograms (280,000 pounds) with a special permit in certain US states. The Triple Transfer usually costs a contractor about $105 an hour while A/B configures usually runs about $85 per hour (2007 stats).

4. **Truck and pup**: A truck and pup is very similar to a transfer dump. It consists of a standard dump truck pulling a dump trailer. The pup trailer, unlike the transfer, has its own hydraulic ram and is capable of self-unloading.

5. **Super dump truck**: A Super dump is a straight dump truck equipped with a trailing axle, a lift able, load-bearing axle rated as high as 5,897 kg. Trailing 3.35 to 3.96 m behind the rear tandem, the trailing axle stretches the outer "bridge" measurement—the distance between the first and last axles—to the maximum overall length allowed. This increases the gross weight allowed under the federal bridge formula, which sets standards for truck size and weight. Depending on the vehicle length and axle configuration, Super dumps can be rated as high as 36,287 kg. GVW and carry 26000 short kg (23600 kg: 23200 long kg) of payload or more. Truck owners call their trailing axle-equipped trucks Super dumps because they far exceed the payload, productivity, and return on investment of a conventional dump truck. The Super dump and trailing axle concept was developed by Strong Industries of Houston, Texas.

6. **Semi trailer end dump truck**: A semi end dump is a tractor-trailer combination wherein the trailer itself contains the hydraulic hoist. A typical semi end dump has a 3-axle tractor pulling a 2-axle semi-trailer. The key advantage of a semi end dump is rapid unloading. A key disadvantage is that they are very unstable when raised in the dumping position limiting their use in many applications where the dumping location is uneven or off level [4].

7. **Semi trailer bottom dump truck**: A semi bottom dump (or "belly dump") is a 3-axle tractor pulling a 2-axle trailer with a clam shell type dump gate in the belly of the trailer[6]. The key advantage of a semi bottom dump is its ability to lay material in a wind row (a linear heap). In addition, a semi bottom dump is maneuverable in reverse, unlike the double and triple trailer configurations described below. These trailers may be found either of the windrow type shown in the photo, or may be of the 'cross spread' type with the gates opening front to rear instead of left and right. The cross spread gates will actually spread gravel fairly evenly the width of the trailer. By comparison, the windrow gates leave a pile in the middle. The cross spreads jam and do not work well with larger materials. Likewise they are not suitable for use where spreading is not desired such as when hot asphalt paving material is being dumped into a paving machine.

### III. CONCEPT

A small scale model has developed using light weight material i.e. plastic and hydraulically operated piston and cylinder arrangement. This hydraulic arrangement actuates on motor driven which makes the prototype semi automatic.
Moreover, battery drives the motor handled using a control panel which is attached with the base model using wires / FRC cable and after that controlled by operator. A conventional dump truck is mounted on a truck chassis and has an open dump box hydraulically operated and hinged at the rear of the truck usually by one or more hydraulic rams that raise the dump box to unload contents at a delivery site. These hydraulic rams are either front loaded or mounted in the underbody and are driven from a gear box power take-off. Hydraulic rams mounted in the underbody provide the capability of the dump body to tip the dump box on a three-way basis, either to the left or right side or to the rear.

*How a typical tipper trucks works?*

The tipping mechanism is the heart of a three-way tipper construction truck. Tipping mechanisms works basically as follows:

**III-A Hydraulic Cylinder**

A hydraulic cylinder is placed below the body of truck longitudinally at one end of the truck, and the piston end of the hydraulic cylinders is connected by the means of a pivot joint to the chassis of truck.

![Figure I. Hydraulic Cylinder Arrangement](image)

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

**III-B Hinge Joint**

The other bottom end of the body of the truck is connected by a hinged joint with the chassis.

![Figure II: Unloading Position](image)

3-way tipper can overcome this problem, as it can unload material on three sides.

**III-C Three Way Tipper Mechanisms**

As already mentioned, a three-way tipper can unload materials in all three sides. To control the sides of tipping *one more* pneumatic cylinder apart from the main hydraulic cylinder is required. Also we require special types of hinge joints in this case.

![Figure III. Tipper Body](image)

The diagram of a 3-way tipper arrangement showing the main hydraulic cylinders are placed at four corners of the chassis (structure). Each of the four corners of the body is connected by a cross joint with the hydraulic cylinders. The cross joint allows the joining members to tilt with respect to two perpendicular axis.
Suppose the side of cylinder 3 & 4 is rear of the vehicle, then by operating cylinder no.1 & 2 will cause rear tipping, operating cylinder 2 & 4 will cause left side tipping, and operating cylinder 1 & 3 will cause right side tipping. Automation of tipping will be possible by using a power pack with PLC control or some similar kind of automation devices.

III-D Axles

Single axle dump trucks are the smallest sized dump truck on the market, tandem axle are standard sized, and the tri axle or multi axle dump truck is currently the largest dump truck available that requires a special permit to be operated and is dependent of State/Provincial laws.

III-E Hydraulic Pumps

One thing you can see is that the advertised "20000-kg splitting force" is generous. A 4-inch piston has an area of 12.56 square inches. If the pump generates a maximum pressure of 3,000 pounds per square inch (psi), the total pressure available is 37,680 pounds, or about 2,320 pounds shy of 20 tons.

Another thing you can determine is the cycle time of the piston. To move a 4-inch-diameter piston 24 inches length, you need \(3.14 \times 2^2 \times 24 = 301\) cubic inches of oil. A gallon of oil is about 231 cubic inches, so you have to pump almost 1.5 gallons of oil to move the piston 24 inches in one direction. That's a fair amount of oil to pump -- think about that the next time you watch how quickly a hydraulic backhoe or skid/loader is able to move! In our log splitter, the maximum flow rate is 11 gallons per minute. That means that it will take 10 or so seconds to draw the piston back after the log is split, and it may take almost 30 seconds to push the piston through a tough log (because the flow rate is lower at high pressures). Just to fill the cylinder with oil, you need at least 1.5 gallons of hydraulic oil in the system. You can also see that one side of the cylinder has a larger capacity than the other side, because one side has the piston shaft taking up space and the other doesn't. Therefore, big hydraulic machines usually have:

- Large appetites for hydraulic oil (100 gallons is not uncommon if there are six or eight large hydraulic cylinders used to operate the machine.)
- Large external reservoirs to hold the difference in the volume of oil displaced by the two sides of any cylinder.

Safety consideration is the leveling of the truck before unloading. If the truck is not parked on relatively horizontal ground, the sudden change of weight and balance due to lifting of the skip and dumping of the material can cause the truck to slide, or even—in some light dump trucks—to turn over. The size and the difficulty of maintaining visual contact with on-foot workers, dump trucks in car parks can be a threat, especially when backing up. Mirrors and back-up alarms provide some level of protection, and having a spotter working with the driver also decreases back-up injuries and fatalities.

IV. Construction

Model has constructed using various material like MDF (Medium density fiber core) hard wood plywood, 3/16 nuts & bolts, aluminum sheet, motors (DC), gearboxes, syringes, wheel screw, nuts, toggle switches, push buttons, battery etc. Firstly, a base chassis structure is prepared using MDF 8mm sheet. The structure is 22” in length and 11” in width. This structure incorporates driving motor along with steering motor. These motors are fixed with a fixed reduction radio gearbox of 100:1 to increase torque and reduce speed of the motor. The wheel base is kept 14” while the track distance to the output slate of the gearbox which is associated with the DC motor and gearbox assembly is fixed in the wheel hub, and it is attached with the chassis using aluminum sheet. A steering rod connects both the wheels of truck with a steering motor.

At the end of this chassis a platform of 26 x 36 cm which are pivoted on each and off opposite sides. So as to four ‘Z’ shaped. Each two platforms are connected using a plastic syringe piston and cylinder assembly that forms the hydraulic piston and cylinder arrangement. Hydraulic fluid in piston and cylinder arrangement pushed and pulled using a head screw arrangement. The proper guide ways and guide slides make the fluid to flow through gearbox and motor. This assembly is of three sections as there are three numbers of hydraulic cylinders that operates the trolley. This power cylinder and piston arrangement is fitted in front of the trolley. These motors are connected to the wired remote that incorporated toggle switches and push button, by manipulating these buttons the entire work can be demonstrated. By operating the push button, motor actuates the piston and cylinder arrangement which pushes the hydraulic fluid to the cylinder beneath. The trolley piston gets out and makes the trolley to tilt by operating various cylinders; the material can be dropped in 3 ways.
V. MATERIAL USED & ITS TECHNICAL DATA’S

A. MDF Sheet

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>SUPERIOR MDF TECHNICAL DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior MDF</td>
<td>3/8” to 1/2”</td>
</tr>
<tr>
<td>Density (lb./ft.)</td>
<td>45</td>
</tr>
<tr>
<td>Internal Bond (psi)</td>
<td>120</td>
</tr>
<tr>
<td>MOR (psi)</td>
<td>3700</td>
</tr>
<tr>
<td>MOE (psi)</td>
<td>450,000</td>
</tr>
<tr>
<td>Face Screw Holding (lbs.)</td>
<td>315</td>
</tr>
<tr>
<td>Edge Screw Holding (lbs.)</td>
<td>N/A</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>5-7</td>
</tr>
<tr>
<td>Thickness swell (%)</td>
<td>10</td>
</tr>
<tr>
<td>Water absorption (%)</td>
<td>14</td>
</tr>
</tbody>
</table>
A. Fleke Board

### TABLE II

**FRBREX HIGH DENSITY THIN MDF TECHNICAL DATA**

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Minimum Specifications</th>
<th>Fibrex8 Average Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metric</td>
<td>Imperial</td>
</tr>
<tr>
<td>Density</td>
<td>&gt;840 kg/m³</td>
<td>52 lb/ft³</td>
</tr>
<tr>
<td></td>
<td>&gt;880 kg/m³</td>
<td>56 lb/ft³</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>4%-9%</td>
<td>4%-9%</td>
</tr>
<tr>
<td></td>
<td>5%-7%</td>
<td>5%-7%</td>
</tr>
<tr>
<td>Formaldehyde Emissions</td>
<td>&lt;0.3 ppm</td>
<td>&lt;0.3 ppm</td>
</tr>
<tr>
<td></td>
<td>&lt;0.2 ppm</td>
<td>&lt;0.2 ppm</td>
</tr>
<tr>
<td>Thickness Tolerance (Raw)</td>
<td>+/-0.2 mm</td>
<td>+/-0.008 mm in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness Tolerance (Sanded)</td>
<td>+/-0.1 mm</td>
<td>+/-0.004 mm in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width Tolerance</td>
<td>+/-0.1 mm/m</td>
<td>+/-1/64 in./ft.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length Tolerance</td>
<td>+/-0.1 mm/m</td>
<td>+/-1/64 in./ft.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squareness</td>
<td>3 mm/m</td>
<td>+/-1/32 in./ft.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 mm/m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+/-1/32 in./ft.</td>
</tr>
<tr>
<td>Internal Bond (&lt;3mm)</td>
<td>&gt;0.62 N/mm²</td>
<td>90 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.90 N/mm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130 psi</td>
</tr>
<tr>
<td>Internal Bond (&gt;3mm)</td>
<td>0.76 N/mm²</td>
<td>110 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.17 N/mm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>170 psi</td>
</tr>
<tr>
<td>MOR (&lt;3mm)</td>
<td>&gt;31 N/mm²</td>
<td>&gt;4500 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;39 N/mm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;5700 psi</td>
</tr>
<tr>
<td>MOR (&gt;3mm)</td>
<td>&gt;34 N/mm²</td>
<td>&gt;5000 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;41 N/mm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;6000 psi</td>
</tr>
</tbody>
</table>

VI. DESIGN CALCULATION

**VI-A. Plate No. 1**

Area of plate (A) 360 × 260 = 93600 mm²

For extreme limit considering factor of Safety

\[ P = W = 0.45 \text{ gm} \times 9.81 = 4.4145 \text{N} \]

Stress = \[ \sigma = \frac{P}{A} = 0.471 \times 10^{-6} \text{N/mm}^2 \]

For working condition

\[ P = 0.225 \text{ gm} \times 9.81 = 2.20725 \text{ N} = 2200 \text{kN} \]

Stress = \[ \sigma = \frac{P}{A} = 0.0235 \text{N/mm}^2 \]

As per standard data for MDF sheet

Young’s modulus (E) = 4 × 10^9 N/mm²

\[ \delta l = \frac{F l}{AE} = \frac{2200 \times 0.360}{0.996} \times 10^{-9} \]

\[ \delta l = 2.11 \times 10^{-6} \text{m} = 2.11 \times 10^{-3} \text{ mm} \]

Elongation (Strain)

Longitudinal strain = \[ \frac{\delta l}{l} = \frac{2.11 \times 10^{-3}}{360} = 5.87 \times 10^{-6} \]

Plate or Platform Weight or

Dumper platform Weight

1 platform (A)

Volume \( V = l \times w \times t \)

\[ = 360 \times 260 \times 5 \]

\[ V = 468000 \text{ mm}^3 \]

Mass = \( V \times \rho \); Where \( \rho \) = Density

\[ = 468000 \times 45 \]

\( \rho = 45 \text{ lb/feet}^3 \) …from chart

\[ = 45 \times 0.4513/0.33 = 67.69 \text{kg/m}^3 \]

1lb = 0.4513kg

1feet = 0.33 m

Volume = 468000 mm³ = 468000 x 10⁻⁹ m³ = 4.68 x 10⁻⁴ m³
Mass = \( 4.68 \times 10^{-4} \times 67.69 = 0.0316 \) kg = 31.6 gm

Weight = 0.0316 x 9.81 = 0.3107 N

**VI-B Plate No. 2**

- **Figure VIII. Plate 2 Dimension**
  - Total Area of plate = 260 \times 360 = 93600 mm\(^2\)
  - Plate B = 90 mm \times 160 mm \times 2 = 28800 mm\(^2\)
  - Plate A = 130 mm \times 90 mm \times 2 = 23400 mm\(^2\)

Area = Total - Plate A - Plate B
  = 41.4 \times 10^3 \ mm^2

Stress = \( \frac{F}{A} \)
  = \( \frac{0.45 \times 9.81}{41.4 \times 10^3} \)
  = 1.06 \times 10^{-4} \text{N/mm}^2

This is max stress for max load i.e. 450 gms

Working stress = \( \frac{F}{A} \)
  = \( \frac{0.24 \times 9.81}{41.4 \times 10^3} \)
  = 5.68 \times 10^{-5} \text{N/mm}^2

Strain = \( \frac{\Delta L}{L} \)
  = \( \frac{4.97 \times 10^{-13}}{360} \)
  = 1.38 \times 10^{-15}

**Plate B**

Total Area platform = 260 \times 360

- **Plate No. 3**
  - **Figure IX. Plate 3 Dimension**
  - Total area of plate = 360 \times 260
    = 93600 mm\(^2\)
  - Section A = 360 x 40 + 100 x 80
    = 22400 mm\(^2\)
  - Section B = 40 x 90 = 3600 mm\(^2\)
  - Area = Total Plate Area – (Section A + Section B)
    = 93600 – (22400 + 3600)
    = 67600 mm\(^2\)
  - V = Area \times Thickness
    = 3.38 \times 10^{-4} m^3
  - Mass = V \times \rho
    = 3.38 \times 10^{-4} \times 67.79
    = 0.0228 kg

Mass = 22 gm

Weight of plate = 0.0228 x 9.81 = 0.223 N
Area of C+ D = \( \frac{1}{2} \times 60 \times 45 \) = 2.7 \times 10^3 \text{ mm}^2

Area of E = 40 \times 40 = 1.6 \times 10^3 \text{ mm}^2

Area of plate which actually bear load = 93.6 \times 10^3 - (20.37 + 630 + 2.7) \times 10^3

Area = 69.9 \times 10^3 \text{ mm}^2

\[ V = \text{Area} \times \text{Thickness} \]

\[ V = 69.9 \times 10^3 \times (5) \]

\[ V = 349.5 \times 10^3 \text{ mm}^3 \]

Mass = V \times \rho

Mass = 3.495 \times 10^{-4} \times 67.79

Mass = 0.0237 \text{ kg}

Weight = 0.02375 \times 9.81 = 0.232 \text{ N}

Weight of total platform = Weight of first platform 1 + platform 2 + platform 3

Weight of total platform = 31.6 + 22 + 25.75

Weight of total platform = 77.35 \text{ gm}

Stress = \( \frac{P}{A} \)

\[ = 0.24 \times 9.81 / 69.9 \times 10^3 \]

\[ = 3.36 \times 10^{-5} \text{ N/mm}^2 \]

\[ \varepsilon = \frac{P}{A} \]

\[ = 0.24 \times 9.8 \times 0.035 / 6.9 \times 10^3 \times 4 \times 10^9 \]

Strain = 2.94 \times 10^{-13} / 360

\[ = 0.816 \times 10^{-15} \]

VI-D Factor Of Safety

Factor of Safety = \( \frac{\text{Max Load}}{\text{Working of design load}} \)

The model can lift max load up to 450 gms

But we have design the project for 240 gms

Hence we get.

F. O. S. = \( \frac{450}{240} \) = 1.8

F. O. S. = 2

VI-E Degree Of Freedom Of Mechanism

The formula for degree of freedom is

\[ = 3 (1 - 1) 2j + K \]

\[ = 3 (3 - 1) - 2 \times 2 = 1 \]

\[ = 1 \]

This is degree of freedom for each plate. In this way we can move each plate in one direction so we have obtained 3 degree of freedom entire mechanism. In pitch roll, yow i.e. in backward direction, right hand side direction and left hand side direction.

1. 1st Plate

\[ \theta = 35^\circ \]

\[ \theta = f(x, y) \]

\[ \theta = f(260, 350) \]

2. For 2nd Plate

\[ \theta = 35^\circ \]

\[ \theta = f(y, z) \]
\[ \theta = f \left( 35^\circ, 6 \right) \text{ mm} \]

Similarly

for third plate we have 35° movement.

**VI-F Calculation For Pressure**

For our mechanism we use “Pascal Law” Hydraulic pressure calculation for l cylinder

\[ P = 4.1320 \text{ N/mm}^2 \]

Total pressure applied \( P = 3 \times 4.1320 \)

\[ = 12.39 \text{ N/mm}^2 \]

From equilibrium condition

\[ P = W \]

Hence

\[ W = 12.39 \text{ N/mm}^2 \]

**VI-G. Calculation For Power Screw**

Angular velocity \( (\omega) = \frac{2\pi N}{60} \)

\[ = \frac{2\pi \times 2.350}{60} \]

\[ \omega = 235.61 \text{ rad/sec} \]

Now velocity of power screw

\[ v = \omega r \]

\[ = 10 \times 235.61 \]

\[ v = 2356.1 \text{ mm/sec} \]

K. E. of power screw \[ = \frac{1}{2} \text{mv}^2 \]

\[ = \frac{1}{2} \times 80 \times 2351.1 \]

K. E. \[ = 94.04 \times 10^3 \text{ Joule} \]

Pitch of power screw = 2 mm

Distance moved by power screw when the platform moved by 80 mm

\[ = 60 \text{ mm} \]

Distance moved (h) = 60 mm

Total No of thread moved when platform or base move up to extreme limit.

\[ = \frac{60}{2} = 30 \text{ thread} \]

Load applied on power screw (W) 85 gm \[ = 85 \times 9.81 \]

\[ = 833.85 \text{ N} \]

Diameter of lead screw (d) is 20 mm

Pitch of lead screw (p) is 2.0 mm

Coefficient of friction = 0.8

Now we have to calculate force

\[ \tan \alpha = \frac{W}{\pi \times 20} \]

\[ = 13.27 \]

Torque required to over come friction at the thread

\[ T = \rho \times \frac{d}{2} \text{ Where } \rho = \text{Force} \]

\[ = W \tan(\alpha + \theta) \times \frac{d}{2} \]

\[ T = W \left( \frac{\tan \alpha + \tan \theta}{1 - \tan \alpha \tan \theta} \right) \times \frac{d}{2} \]

\[ = 833.85 \left( \frac{12.27 + 0.8}{1 - 12.27 \times 0.8} \right) \times \frac{20}{2} \]

Torque = 12200 Nmm

We know the torque at power screw

\[ 12200 = \rho \times \frac{d}{2} \]

\[ 12200 = \rho \times 10 \]

\[ \rho = 1220 \text{ N} \]

Force required at power screw = 1220 N

Maximum compressive stress in the screw

\[ \delta c = \frac{W}{A} \times \frac{d^2}{4 \times 2^2} \]

\[ = \frac{833.85}{2^2 \times 20^2} \]

\[ \delta c = 2.65 \text{ N/mm}^2 \]

Bearing pressure on the thread

No. of thread in contact with the nut

\[ = \frac{60}{2} = 30 \text{ thread} \]

Thickness & thread = \[ = \frac{p}{2} \text{ p= pitch} \]

\[ = \frac{0.2}{2} \]
We know that bearing pressure on thread

\[ P_b = \frac{W}{\pi d t n} \]

Where
- \( W \) = Load applied on power screw
- \( d \) = Diameter of power screw
- \( t \) = Thickness of thread
- \( n \) = No. of threads moves upward

\[ P_b = \frac{1220}{2.14 \times 20 \times 0.1 \times 30} \]
\[ P_b = 6.47 \text{ N/mm}^2 \]

Maximum Shear stress in the thread

\[ \tau = \frac{16 \tau}{\pi d^3} \]
\[ \tau = \frac{16 \times 12000}{\pi \times 20^3} \]
\[ \tau = 7.76 \text{ N/mm} \]

\[ \tau_{\max} = \frac{1}{2} \sqrt{(6\tau)^2 + 4\tau^2} \]
\[ \tau_{\max} = \frac{1}{2} \sqrt{(2.65)^2 + 4(7.76)^2} \]
\[ \tau_{\max} = 7.87 \text{ N/mm} \]

Efficiency of Screw

\[ \eta = \tan \frac{\alpha}{\tan(\alpha + \theta)} \]
\[ \eta = 13.27 \frac{1-12.27+0.8}{12.27+0.8} \]
\[ \eta = 90.69 \% \]

VII. ADVANTAGES & DISADVANTAGES

- Increased moving ability :
  Thus, it does not become tiresome to perform the job.
- Can be used in very compact places :
  Where reversing & turning of vehicle is difficult.
- Accommodate on dam site working.
- Saves time & energy.
- Increased complexity:
  It requires complex mechanism for getting desired output.

- Cost increases :
  More complications lead to increase in cost.
- Increase in Maintenance.

VIII. FUTURE SCOPE

World progressing at faster rate which demands efficient working equipments such as user friendly machineries and hence the three way dropping dumper may be used more than the two way or one way.

The work can be modified further more on following basis:-
- Dual stage cylinders can be used.
- Oil pump can be used instead of powered cylinder.
- Capacity can be increased.
- Four wheel steering can be adopted for more movement ability

IX. CONCLUSION

The developed prototype exhibits the expected results. Further modifications and working limitations will put this work in the main league of use. This concept saves time & energy which leads to efficient working. This further line should be modeled using equations and an experimental agreement. The constructional work or the infrastructural work demands efficient and user friendly machinery which will lead to more and more use of three way dropping dumper.

REFERENCES