

## Proof of Concept Fabrication of Multi-axis Pneumatic Mechanism for Dumpers

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### ABSTRACT:

*At many building sites there isn't sufficient space to manoeuvre the dumper in various directions to discharge the material to the front and side ways. In such situations, there is a growing demand of multi-axis articulated dumpers. This work deals with the fabrication of scale down prototype of three way dropping dumper wherein the dumper is operated using pneumatic tilting mechanism. There are three hydraulic cylinders which are operated by motor and gearbox to tilt the dumper body in all three directions. To maintain optimum efficiency of pneumatic system, the pressure drop between generation and consumption of compressed air is kept very low. Based on the initial prototype and tilting trials, it is demonstrated that this multi-axis system can be fully implemented in large scale. Further, the proposed pneumatic system can be automated with additional control system replacing the socket-pin arrangement to change the tilt directions with minimum human intervention.*

### KEYWORDS:

*Modern dumper; Pneumatics; Compressor; Multi-axis articulation; Mining material handling*

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## 1. Introduction

A dumper is a vehicle designed for carrying bulk material, often on construction or building sites. A dumper is usually an open 4-wheeled vehicle with the load skip in front of the driver. The skip can be articulated to dump the load. A towing eye is fitted for secondary use as a site tractor. Modern dumpers [1] have payloads of up to 10 tonnes and usually steer by articulating at the middle of the chassis (pivot steering). They have multi-cylinder diesel engines, some turbo charged, electric start and hydraulics for tipping and steering and are more expensive to manufacture and operate. A rollover protection frame may be fitted over the seat to protect the driver if the dumper rolls over. Some dumpers have falling object protection as well. Lifting skips are also available to discharge materials above ground level. In the 1990's 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 at construction sites. One of the problems with dumper is the time and energy for setting the heavy dumper in proper direction to dump the material.

Hydraulics were incorporated into truck mounted dump bodies relatively early on, for example, Robertson Steam Wagon had a hydraulic hoist that received power from the truck's engine or an independent steam engine. In 1907, Alley & McLellan developed another hydraulic dump body that was power-driven by steam. The ability of dump trucks to deliver rapid unloading capabilities resulted in the development of hopper type dump body. The dump body was elevated with struts and beams

located underside in a scissor like pattern. Pulling the beams close together automatically elevated the dump body. Elevating the dump body allowed the free flow of material by gravity along chutes and for some distance from the truck. The side dumper mechanism dumps the material either in right or left plain of the trailer according to the buyer's need and specification. These side dumpers were not really produced in large quantity since their frame design was so expensive.

At many building sites there isn't sufficient space to manoeuvre the dumper in various direction also there are some sites wherein the material is supposed to be discharged in all the three directions – front, left and right sides of the skip without moving the vehicle in any direction. This work deals with the fabrication of laboratory scale prototype of three way dropping dumper wherein the dumper is operated hydraulically. There are three hydraulic cylinders which operates the dumper in all three directions. These hydraulic cylinders are operated by motor and gearbox. Being a proof of concept fabrication, low weight materials are handled in this project. The dumper is constructed using various materials like MDF, aluminium sheet, universal joint, solenoid switches, dump body and pneumatic piston.

## 2. Fabrication of prototype dumper

A small scaled down prototype of the dumper is fabricated to demonstrate the working principles of pneumatic mechanism as a proof of concept. Pneumatic rams [2], driven by compressed fluid (air), are mounted under the dumper body to tip the dump box on a three way basis, either to the left or right side or to the front.

The chassis structure is prepared using mild steel rod of hollow square with outer dimension of 15×15mm and an inner thickness of 4mm. The structure is 370mm in length and 250mm in width. The wheel base is kept as 30 mm. The height of chassis is 210mm from wheel centre. The wheels are offset 4mm from the chassis. This avoids slipping or sliding of vehicle during dumping action. To mount the pneumatic cylinder and the solenoid switch, two cross members were provided under the frame [3]. A steel plate of dimension 220×20×5mm is used for the cylinder mount with a holding clip of 18mm diameter with a 14mm diameter hole at the centre of the plate. The pneumatic cylinder is attached to this clip with a help of Halen’s key. The solenoid switch is fitted with ordinary screws on the other cross member of dimension 220×70×5 mm. The graphical representation of the arrangement of various components is shown in Fig. 1.

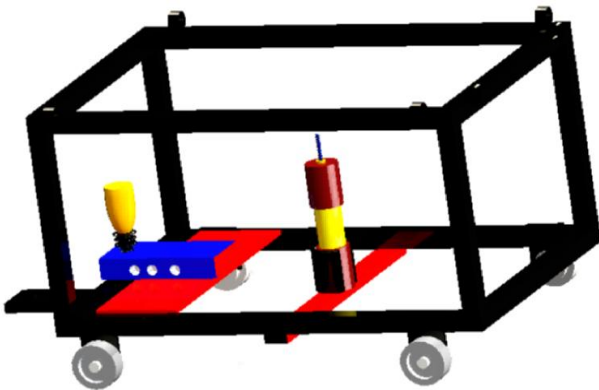


Fig. 1: CAD model of multi-axis dumper – Chassis and mounts

The dumper body comprising the floor and three articulated side doors is fabricated using aluminium sheet of 1mm thickness. The dimension of the floor is 370×250mm. The dimensions of the side and front doors are 350×20mm and 250×20mm respectively. These doors are joined to the floor by simple bolt and nut arrangement at the top [4]. The universal joint is fitted at the bottom of the platform such that its hole will perfectly align with the pneumatic cylinder as shown in Fig. 2. In order to eliminate the damp force in the dumper body, the shaft on one side of the universal joint is welded with the platform such that the damping force travels from the vehicle body to the wheel [5-6].

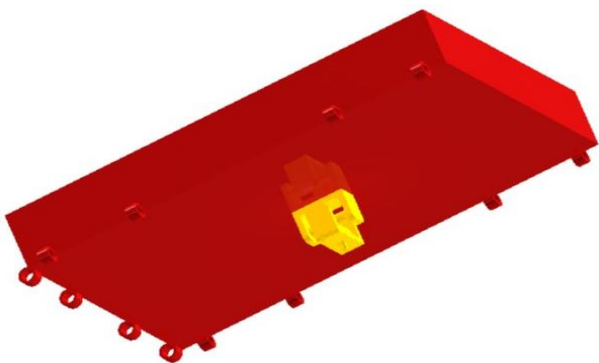


Fig. 2: CAD model of dumper body and its universal joint



Fig. 4: Photographic views of the successfully fabricated innovative multi axis pneumatic dumper

The direction of dumper articulation is controlled by socket pin arrangement [3] which can be changed manually by the user. This socket joins the chassis and dumper body together. The tilt mechanism uses the stored energy of fluid (compressed air) to action the pneumatic cylinder. Before operating the prototype, checking of connections are mandatory because leakages may lead to false operation of the setup. Once everything is set, the side of the dumper in the tilt direction is locked using ball and socket pin system. Once the pin is set in its place, the solenoid valve releases the air from the compressor to flow in to the cylinder and performing the dumping action in the previously set direction. After completing the dumping action, the frame is brought back to its place by the self-weight of the dumper body. The frame can be hold in its tilt position if required until the solenoid valve is reversed. The frame movement is restricted to a predetermined angle in side axis dumping action when compared to the front axis dumping in order to prevent the slipping or flipping of the trailer by the dumping load itself. The photographs of the dumper discharging material in the front axis and side axis are shown in Fig. 5 and 6 respectively.



Fig. 5: Photograph showing dumper discharging front ways



**Fig. 6: Photograph showing dumper discharging side ways**

Before integrating this innovative multi-axis tilt mechanism using pneumatic rams in actual dumper, further studies such as the use of shock absorption for pneumatic action and detailed calculation of required torque based on the payload weight and dumper body space [7] must be performed. The tilt angle in the side axes is restricted such that the vehicle stability is not compromised. However, the objective as proof of concept of this new multi-axis tilt mechanism has been demonstrated well and tested many times for the repeatability of tilt as well as retraction of tracks. There were no noticeable disruptions in repeatable operation of the pneumatic system.

### 3. Conclusions

An innovative pneumatic based multi-axis tilt mechanism for heavy duty dumper has been designed and then fabricated as a scaled down prototype to

demonstrate its functioning as proof of concept. The solenoid valve based engagement and disengagement of pneumatic rams has proved the efficient working of dumper to discharge the payload to the front, left and right sides. As this concept saves time and energy as well this may leads to efficient working in tighter manoeuvring space such as at mining and dam construction sites.

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### EDITORIAL NOTES:

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