Design and Development of Multistage Dumping Trolley

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Abstract— Conventional dumping trolley operates on hydraulic system to dump the material on back side only. The areas where limited space is available, one side dumping is not feasible. So provision of dumping on either side is developed through the concept of Multistage Dumping Trolley (MSDT). This paper presents design and development of MSDT operates on pneumatic system. The multistage dumping is accomplished by design of frame locking mechanism. It consist integrated chassis design for multi-side dumping. This Multistage Dumping Trolley is in developing stage.

Index Terms— Chassis design, Frame locking mechanism, Multistage dumping, Pneumatics

I. INTRODUCTION

Dumping trolley is mostly used for agricultural purpose to carry and dump the material. The conventional dumping trolley is operated on hydraulic system and dumps material at backside of trolley only. In case of narrow lanes and limited spaces, dumping is difficult with conventional trolley. In MSDT, when high pressurized air (kinetic energy) is converted to mechanical linear actuation with the help of actuator, it is responsible for dumping operation. Three side dumping is achieved by frames locking mechanism. This locking mechanism is incorporated in design of chassis. Thus, the particular stage of dumping is possible by unlocking respective frame.

II. PARTS OF TROLLEY

Fig. 1 Model of MSDT

A. Chassis frames

Chassis is made of four frames namely upper frame, middle frame, lower frame and base frame.

B. Load carriage

This carriage carries load or material to dump.

C. Locking strips

Three locking strips fitted to all frames excluding base frame to lock two frames with each other.

D. Hinges

Five hinges are fitted on frames to tilt the trolley on desired side.

E. Dumping shaft

The dumping shaft is fitted within upper frame and connected to piston rod of dumping actuator.

F. Actuators

Pneumatic actuators are fitted within frames. Actuators are used for dumping and locking the frames.

G. Direction control valve

5/2 direction control valve is used in pneumatic circuit for directing pressurized fluid to actuators.

III. DESIGN AND CONSTRUCTION

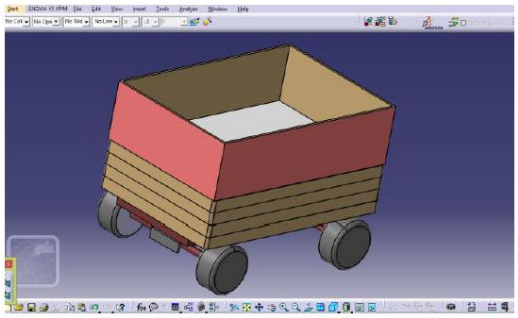

Fig. 2 Assembly drawing in CATIA

Fig.1 shows assembly of dumping trolley consisting chassis frames, load carriage, locking strips, hinges, actuators and dumping shaft.

1. Chassis frames

Frame is the structure of the model, they support and help in mounting of actuators on it for locking purpose. A frame is made up of mild steel and hallows square shape.

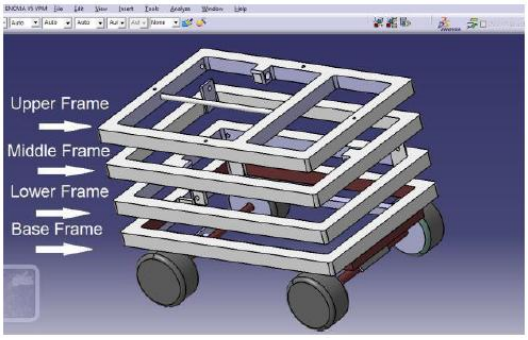

Fig. 3 Chassis frames

There are four frames used in the model as shown in fig.2:

1. Upper frame 2. Middle frame
3. Lower frame 4. Base frame

2. Hinges and Locking strips

Hinges are used to connect the frames and are made up of steel. During dumping stages, hinges accomplish the purpose of tilting the respective frame. The locking strips are made up of mild steel used for locking particular frame when respective cylinder actuates. Three locking strips are fixed on frames 2, 3 and 4 for locking the frame 1-2, 2-3 and 3-4 respectively.

3. Actuators

Fig. 4 Pneumatic actuators

Three locking actuators of 16 x 25 and one dumping actuator of 25 x 100 are used for locking and dumping respectively. The thickness of cylinders according to required pressure and forces are selected using standard Clavarino's Equation:

$$T = r_i \cdot \left[\frac{\sqrt{\sigma t + (1 + 2\mu)P}}{\sqrt{\sigma t + (1 + \mu)P}} - 1\right]$$

Material of piston is Aluminum, σ_t=200N/mm^2 Assume, p = 3 bar =0.3 N/mm^2, μ = 0.36, r_i = 25mm Substituting above values,

we get, t= 0.031mm.

The piston rod is designed by standard Rankin's formula:

$$\sigma_t = (\sigma_u/FOS)$$

Where, FOS=Factor of Safety(Assuming FOS=1.5) We get, d=5 mm.

4. Direction control valve

Fig. 5 Direction control valve

5/2 direction control valve is used in this model to execute forward and return strokes of the piston during dumping stages. Manually lever operated 5/2 direction control valve is used in pneumatic circuit.

IV. PNEUMATIC CIRCUIT

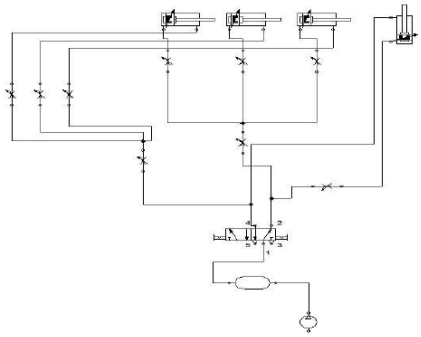

Fig. 6 Pneumatic circuit

Basic circuit of MSDT is pneumatically operated. During forward stroke by DCV the compressed air is directed by Y type valve to dumping actuator as well as locking actuators. For locking actuator, the locking operation is controlled individually by shut-off valves. During return stroke the second position of DCV executes return of dumping actuator and unlocking of frames respectively. Maximum operating pressure of circuit is up to 4-5 bars.

V. STAGES OF MSDT

1. Back side dumping:

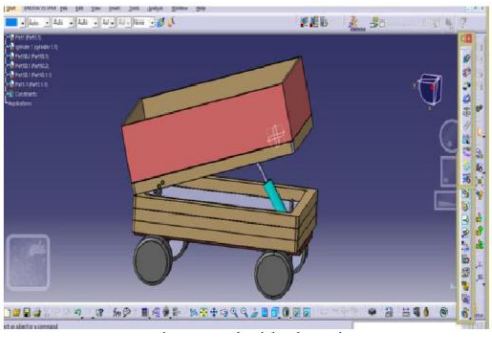

Fig. 7 Back side dumping

During backside dumping, first locking actuator kept unlocked by shut-off valve and remaining two becomes locked during operation. Thus in forward stroke first frame is tilted towards backside by actuating dumping actuator.

2. Left side dumping:

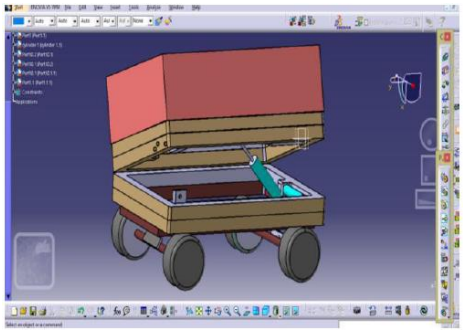

Fig. 8 Left side dumping

During left side dumping, second locking actuator kept unlocked by respective shut-off valve and remaining two becomes locked during operation. Thus first and second frame in locked condition are tilted towards left side by actuation of dumping actuator.

3. Right side dumping:

During right side dumping, third locking actuator kept unlocked by respective shut-off valve and remaining two becomes locked during operation. Thus first, second and third frame in locked condition are tilted towards right side by actuation of dumping actuator.

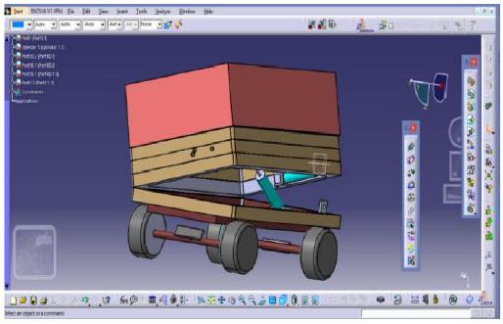

Fig. 9 Right side dumping

VI. CONCLUSION

The developed prototype model of multistage dumping trolley can be used to dump the material at any required side. Thus, the limitations of conventional tractor-dumping trolley can be overcome. Development of multistage dumping trolley is achieved by integrated chassis design which includes locking mechanism of frames. The frame locking mechanism operates on pneumatic system gives easy and effective locking of frames to accomplish multistage. Thus it saves energy as well as time required for dumping with efficient working of trolley.

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