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Design and Fabrication of a Vacuum Breaker Device to avoid Tank Distortion

Aishwarya Khilari[1], Mohini Hande[2], Aditya Bhoj[3], Bhushan Landge[4], Tukaram Sargar[5]

[1]*UG Student, Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering. aishwaryak1911@gmail.com*

[2]*UG Student, Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering. handemohini27@gmail.com*

[3]*UG Student, Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering. adibhoj@gmail.com*

[4]*UG Student, Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering. landgebhushan39@gmail.com*

[5]*Assistant Professor, Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering. sargartukaram@gmail.com*

ABSTRACT

Safety is one of the utmost important factors to be considered while using the equipments which are highly expensive. The processing plants include chemical conversions, pharmaceuticals, beverages, powder, food, etc. The equipments include tanks, valves, filters, heat exchangers, piping, etc., which are costly and need to be handled and used with high precautions. Silo tanks are used around the world by many companies to store huge amount of any substance without putting it at risk. The construction material used for making the silo tanks are steel, aluminium, wood, or even concrete. The storage capacity of this tanks is around 1000-5000 litres and the cost of each tank ranges around 1.5 lakhs to 5 lakhs per unit. The height is around 10feet to 20feet. So it is not feasible to do the repairing work so high up and if there is any damage, it would lead to a financial crisis for the entire project. One of the major reasons for damage to the silo tank is negative pressure. To avoid this, the vacuum built-up inside should be broken by some means to avoid the huge loss of resources. There can be any technical obstructions in a manufacturing plant such as electricity supply cut, equipment failure, damage due to loads and stresses, or working conditions. By studying all the possibilities, we design a device with simple mechanism, which is reliable and cost efficient as a safety device.

Keywords- *safety, distortion, negative pressure, mechanical device, vacuum.*

INTRODUCTION

In this paper, a safety device has been suggested to protect the silo tanks from distortion. It is major issue faced by powder manufacturing industries that the tanks which are used for processing the powder (silo tanks) have some negative pressure inside them and if the intake to the tank stop suddenly due to any technical error, the vacuum is created inside when the negative pressure exceeds its limiting value, and the tank squeezes in.

This major failure leads to huge economical loss. This device is based totally upon the ratchet mechanism and no external power supply or components are required for its functioning. The device will break the vacuum built up inside the tank by taking in the atmospheric air and establishing an equilibrium into the system. Once the equilibrium is achieved, the intake of atmospheric air stops and the system takes its original position with the help of ratchet.

The stress analysis of the device is to be done in ANSYS software by considering the loads which could be acted upon it. The results obtained from numerical solution and analytical solution are compared and verified.

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Safety valve is a valve that act as a protection of equipment from exploding or damaging and it is mainly installed in pressure vessels such as chemical plants, electric power boilers and gas storage tanks. Safety Valve is a type of valve that automatically actuates when the pressure of inlet side of the valve increases to a predetermined pressure, to open the valve disc and discharge the fluid (steam or gas); and when the pressure decreases to the prescribed value, to close the valve disc again. [1].
In the study regarding the hydraulic pressure control system Most variable hydraulic loading machines uses traditional counter balance valve to create the opposing hydraulic force [2].
The air filters in an air intake system permanently removes foreign particles such as dust, dirt and soot from the intake air, thereby maintaining the performance of the engine and protecting it from damage. Proper maintenance can help vehicles perform as designed, thereby positively affecting fuel economy, emissions, and overall drivability [3].
Negative pressure relief valve in the scavenging of gases from anesthetic circuits may present hazards to the patient the negative pressure relieve valve prevent generation of sub atmospheric pressures in in the circuit as result of discrepancy between the fresh gas flow and evacuation rate. The ideal valve will open at small negative pressure, and immediately permit a high gas inflow leakage with positive pressure in the circuit [4].
Following are the objectives and scope of the proposed work: -
1) Avoid economic loss of powder manufacturing industries due to damage of silo tanks. 2)Build cost-efficient and effective design.
3) To study various possible safety devices. 4)Selection of most suitable mechanism for problem.

DESIGN OF DEVICE

A design of the safety device, named vacuum breaker is proposed. This device works on a simple mechanism without the requirement of any external supplement such as electric power or hydraulic and pneumatic system. The vacuum breaker is designed in such a way that the vacuum built-up should not take place inside the tank when the negative pressure exceeds the limiting value. The device has two components; the upper body(hopper) and the lower body (cubical box).
The vacuum breaker's lower body, that is the box is connected to silo tank, the hopper end is open to atmosphere and it has air filter fitted inside it. The purpose of air filter is to filter out the contaminants from the air which is to be taken inside the system. The powder inside cannot sustain the contaminants because it is required to retain the purity. There is a movable plate at the interface of hopper and box which acts as a flap. This plate is connected to a lever outside the box. This lever is responsible for the movement of plate aided by a bearing for smooth movement.
When vacuum starts to build up inside the tank, the pressure inside is lesser than atmospheric pressure. So, this pressure difference forces the plate to open in the downward direction and intake of air into the system takes place there. After equilibrium is achieved and vacuum is removed, the plate shuts the opening between the interface. The plate opens only when the dead weight attached to it, allows it to open. The dead weight is adjusted according to the pressure consideration. Basically, dead weight holds the plate. The lever's other end is connected to a Ratchet. The ratchet is responsible to keep the plate unviolated either open or closed. The ratchet knob has to be adjusted manually after each run.

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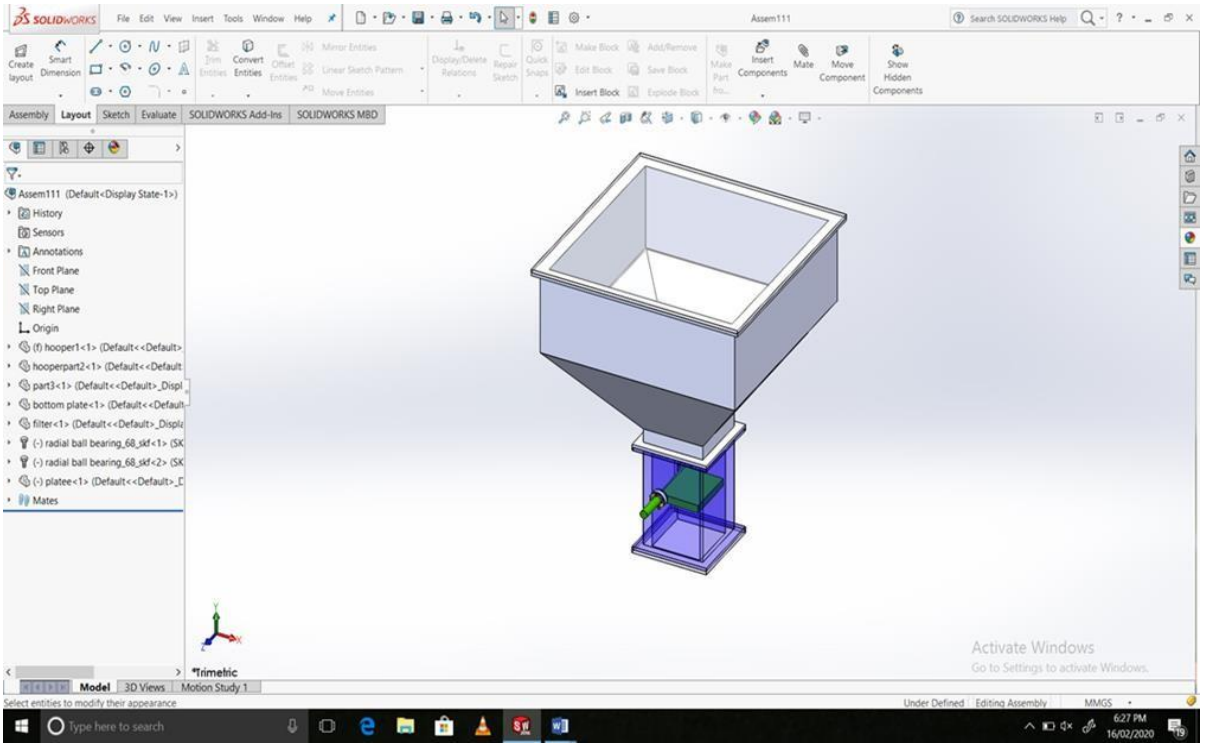

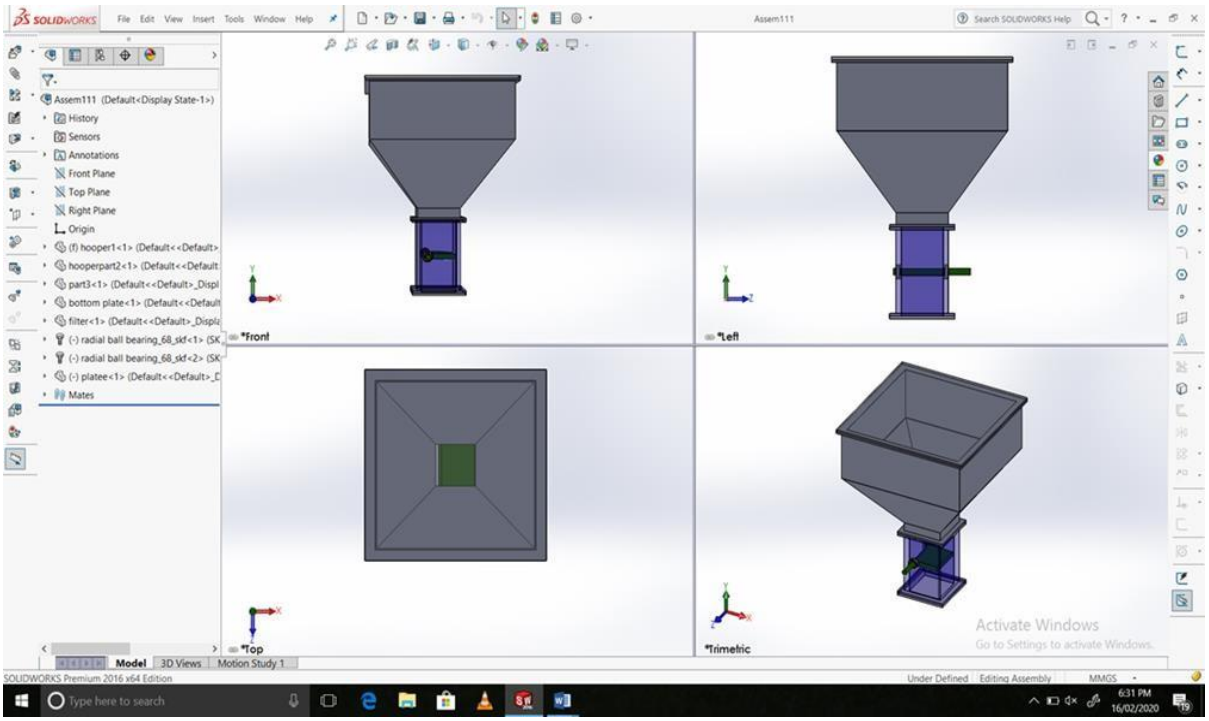

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Plate:

Length of plate = 0.2 m

Area of plate = 0.2×0.2 = 0.04 m^2 Density of stainless steel = 7700 kg/m^2 Thickness of plate = 0.005 m
Moment m_A is calculated as,

$M_A = [P_{atm} \times A \times (L/2)] + [W \times (L/2)] - [P_{in} \times A \times (L/2)]$

$= [(10^5 \times 0.2 \times 0.2 \times 0.1) + (\varrho \times g \times v \times 0.1) - (3 \times 10^5 \times 0.2 \times 0.2 \times 0.1)]$

$= [400 + (7700 \times 9.81 \times 0.2 \times 0.2 \times 0.005 \times 0.1) - 1200]$

$= [400 + 1.51 - 1200]$

$M_A = -798.49$ Nm

In order to balance this moment, dead weight is applied at the end.

$798.49 = m \times g \times l$ $798.49 = m \times 9.81 \times 0.1$ m = 30 kg
Hence, if the mass of 30 kg is applied at the end of bar the pressure is balanced.

RESULT AND CONCLUSIONS

We have selected a mechanical safety device instead of other devices. Hydraulic and pneumatic devices are smaller in size and amount of air entering through it, also will be less. Mechanical device required less processing time. If we use Hydraulic and pneumatic device, special arrangement or system is required to operate the device. Special provision for the oil and air supply required. A Mechanical device does not require electric supply for its functioning.
Mechanical device requires less maintenance compared to hydraulic and pneumatic system.
Mechanical devices are simple in construction, H&P system is complicated and bulky.
Mechanical device is more durable due to rugged construction.

By considering mechanism of dead weight pressure relief valve and with the help of ratchet mechanism the device is designed to break the vaccum inside the tank.

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