Analysis of General Purpose Compactor

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Abstract- **Compactor is a garbage bin designed to compress garbage that is put in it and it is located inside the transportation vehicle of municipality. It is designed in order to avoid spilling of garbage on the roads which results into spread of diseases, disturbing pure ambience, excess handling cost etc. Compactor is a simple mechanism involving use of manual force to control the working of pneumatic or hydraulic system. A compactor consists of cylindrical shell or bin in which the garbage is collected from the hopper which is mounted at the top end of cylindrical shell. The compaction is performed through the action of pneumatic cylinder and piston that is mounted upon the cylindrical shell which rams the Municipal solid waste (MSW) into a cylindrical shaped space in the form of compacted cake. The ejector cylinder is placed at the bottom of the compactor in order to eject the compacted garbage from compactor to the storage space of municipal transportation vehicle. The compactor is to be designed and analyzed such that the whole system sustains the compaction pressure and maintain structural stability. It is mainly targeted to areas like housing societies, big educational institutes, malls, theaters etc.**

Keywords- **Transportation vehicle, MSW, Compaction pressure, Cylindrical shell.**

I. INTRODUCTION

The rising urbanization and change in lifestyle and food habits the amount of municipal waste has been increasing rapidly and its composition has been changing. Because of existence of insufficient and inefficient material collection, according to Ministry of Environment and Forests the collection efficiency of Municipal Solid Waste (MSW) is only around 60% and the rest 40% lies uncollected and scattered all over our towns and cities, polluting the surrounding land and water resources [1]. This also leads to proliferation of rodents and vectors spreading diseases in human and animals and also pollutes air from dust and smoke when burnt in the open. Although some parts of all waste have to be eventually land-filled despite best efforts at segregated collection and treatment, inefficient storage and transportation of source segregated waste necessity land disposal, which is the most expensive option for solid waste management anywhere in the world [4]. Hence there is urgent need of developing efficient waste handling system which can be effectively used for MSW handling.

II. EXISTING MSW HANDLING SYSTEM

In present garbage distribution scheme there are various issues regarding handling, storage and transportation of municipal solid waste which is unnecessarily spoils the environment and creates unpleasant condition to nearby areas as shown in Fig. This existing system creates problem in handling and storage during transportation and disposal [2]. If we channelize this system in proper manner we can overcome the problems which we presently faced.

Fig. 1 Present Garbage Distribution Scheme

III. PROBLEM IDENTIFICATION

a. As the garbage is to be collected in loose form, there has been a major chance of spilling of garbage on roads.
b. The spilling of garbage on road caused pollution of the surrounding land and water resources, which also increases the chances of blockage of pipe lines in rainy season.
c. As the waste is to be collected in loose form, it increases the handling and storage cost.
d. The cost of man handling also increases as the garbage is to be collected and stored in loose form.
e. The transportation cost of MSW gets increases, as the requirement of daily collection trips of loose waste handling vehicle gets increases.
f. The existing waste handling systems gives hazardous effects for the person who handling the waste.

IV. PROPOSED MECHANISM

In order to minimize the effect of current garbage distribution scheme, the proposed general purpose garbage compactor is developed. A compactor is a garbage bin designed to compress garbage that is put in it. It is designed in order to avoid spilling of garbage on the roads which results into spread of diseases, disturbing pure ambience, excess handling cost etc. It is simple mechanism involving use of manual force to control the working of hydraulic arrangement; compactor is mainly targeted to areas like houses, malls, theatres, housing societies, big educational institutes etc. Following are the benefits of proposed waste handling system.A.

- As the garbage is to be compacted, so more space is available for the storage of garbage.
- As the MSW we achieved in fully compacted form, the handling cost gets reduced.
- As the large quantity of garbage gets compacted, the transportation cost of vehicle may be reduced.
- As this compactor avoids the spilling of garbage on road, so the hazardous effects due to spilling of garbage will reduce.
- This compactor inhibits vectors and insects from reaching the waste during collection and transport.
- As the drainage holes are provided at the bottom of cylindrical shell, it may deodorize the compacted garbage.
- It can be subsidize by the government, as it reduces the cost of processing of garbage.

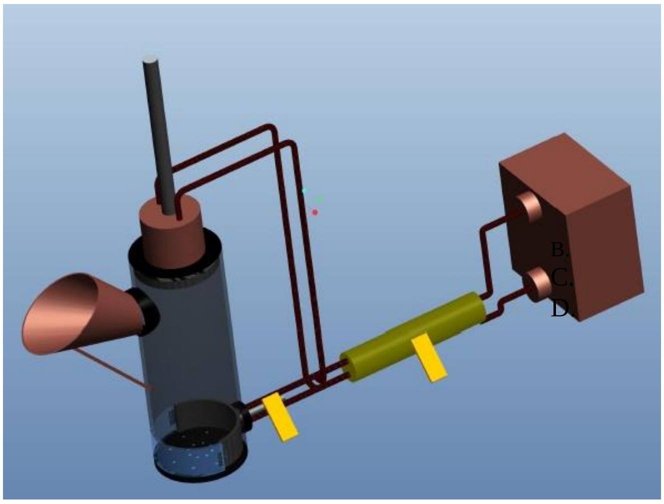

Fig. 2 PROE Model of Proposed Mechanism

V. ANALYSIS OF MODEL

In this analysis of model a static structural analysis of the collector along with the cylinder body will be performed to identify that the system is able to handle the weight of the feeded garbage without generating too much of deformation. Model was imported from Pro-engineer 4 in an IGES format into Ansys work bench.

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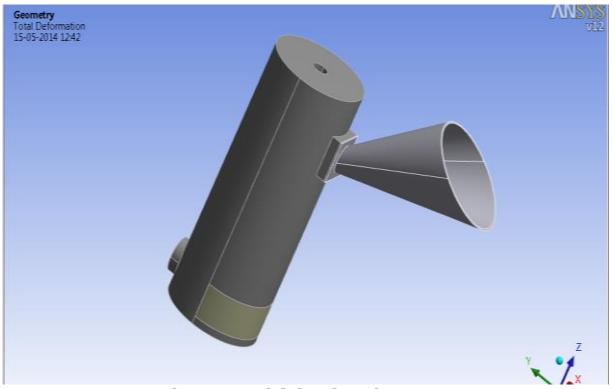


Fig. 3 Actual CAD model developed in Pro-engineer

ANSYS Meshing technology provides a means to balance accurate results and obtain the right mesh for each simulation in the most automated way possible. In mesh generation, finite elements were generated with an average element size of 4mm.

TABLE I. NUMBER OF NODES AND ELEMENTS IN MESHING

Sr. No.	Nodes	Elements	Mesh Metric
1.	233126	133447	None

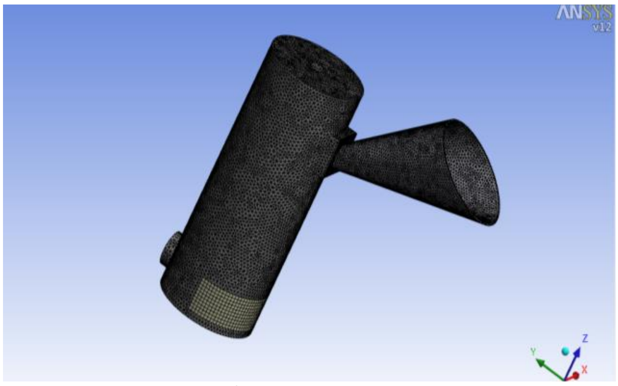


Fig. 4 Mesh Generation for combined hopper and cylinder

As the CAD model was generated by taking in to consideration that the weight of each pass of garbage inside the hopper is around 7 kg. Therefore, force value of 68.67 N was given as a boundary condition. The reason for this is to account for the fed mass of garbage that is dropped in every interval.

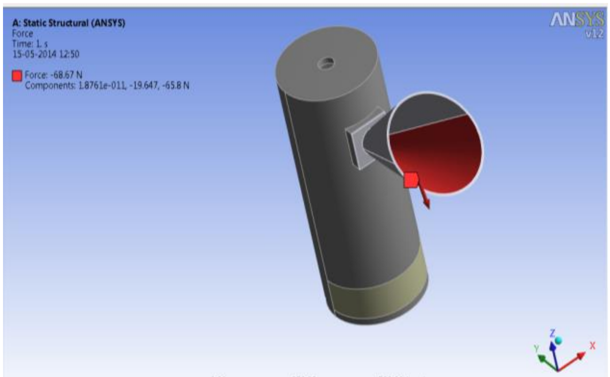


Fig. 5 Boundary condition for force

Results of Structural Analysis of Cylinder and Hopper-

According to the Von-misses theory, the maximum stress induced at the connection between the hopper system and cylinder was about 0.3493 Mpa. Since, the Von-misses stress value was less than that of yield stress of steel i.e. (Sys= 218 Mpa). Therefore, the combined hopper and cylinder system were structurally stable.

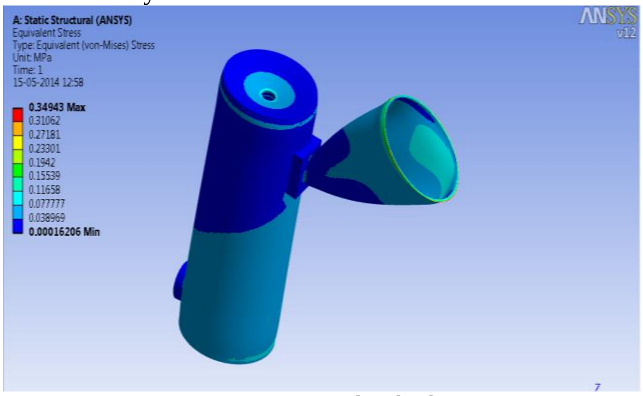


Fig. 6 Von-misses stresses induced in hopper

The deformation results show that, the maximum deflection was negligibly small i.e. 0.00033 mm. Since this value of deflection was far below the failure limits i.e 2mm, therefore the combined system of hopper and cylinder were structurally stable.

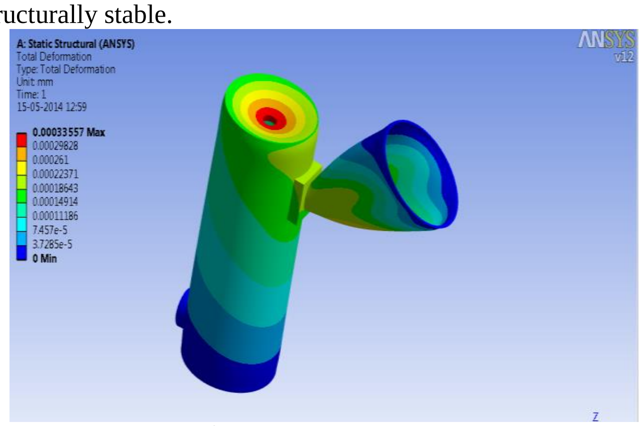
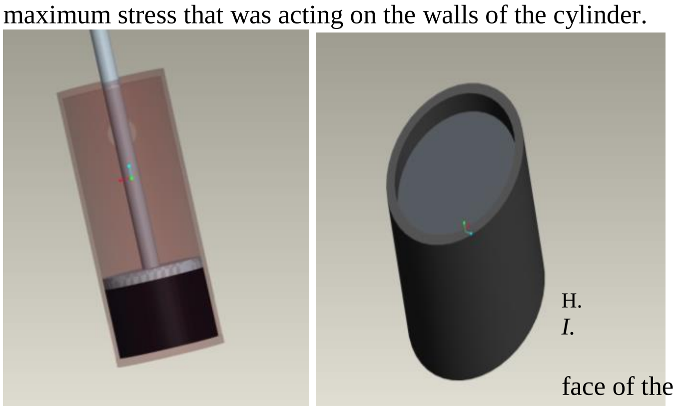


Fig. 7 Deformation in cylinder and hopper

To Simulate the end stage of the compaction process, the compacted garbage was considered to be 90% compacted. So, the final 10% of the compaction was simulated to find the maximum stress that was acting on the walls of the cylinder.



H.
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Fig. 8 Actual and Corresponding model of the end portion of the cylinder with garbage material

TABLE II. MATERIAL PROPERTIES OG GARBAGE MATERIAL

Sr. No.	Property	Value	Unit
1.	Density	591	Kg/m^3
2.	Young's Modulus	1.1E+06	Pa
3.	Poisson's Ratio	0.2	-

TABLE III. MATERIAL PROPERTIES OF STEEL

Sr. No.	Property	Value	Unit
1.	Density	7850	Kg/m^3
2.	Coefficient of thermal expansion	-	-
3.	Young's Modulus	2E+11	Pa
4	Poisson's Ratio	0.3	-
5.	Tensile Yield Strength	2.5E+08	Pa
6.	Compressive Yield Strength	2.5E+08	Pa
7.	Tensile Ultimate Strength	24.6E+08	Pa
8.	Compressive Ultimate Strength	0	Pa

ANSYS Meshing technology provides a means to balance accurate results and obtain the right mesh for each simulation in the most automated way possible. In mesh generation, finite elements were generated with an average element size of 10mm.

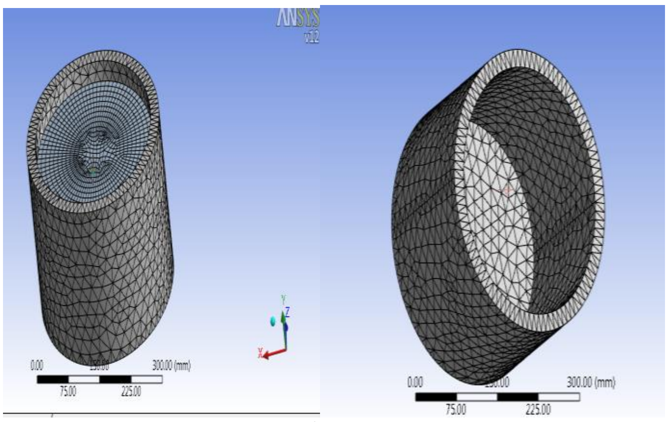

Fig. 9 Mesh generation for compaction process

In this compaction process a pressure of 6000Pa on the top garbage material was given.

P = Weight of Piston(F)/ (Cross section area of piston(A) + 3×Pressure generated due to fluid

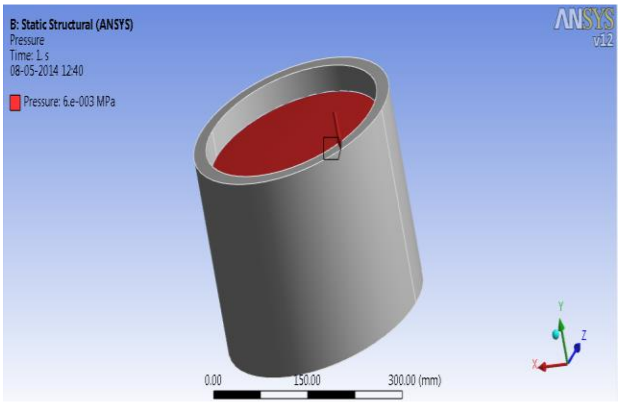

Fig. 10 Boundary condition for compaction process

Results of Compaction Test Analysis-

The Von-Misses Stresses on the combined system of Garbage and the cylinder wall is given in the following figure. This shows that the maximum stress that occurs on the combined system is 0.0185 Mpa which is far below the yield stress of the steel i.e. 245Mpa. This shows that the cylinder wall is structurally stable and can withstand the compaction process.

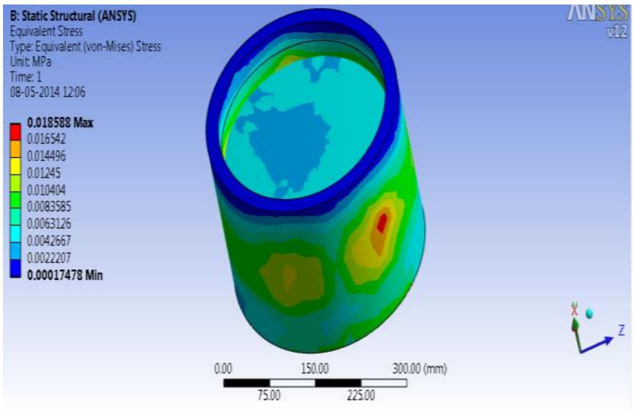

Fig. 11 Equivalent stress distributions on garbage and cylinder wall

Figure 12 shows the Von Misses stress pattern that occur at the inner wall of the cylinder. The maximum stresses occur in the inner regions and stresses decrease as we go radially outward. Hence the regions on the inner cylinder wall are having greater regions of red bands (i.e. greater stresses)

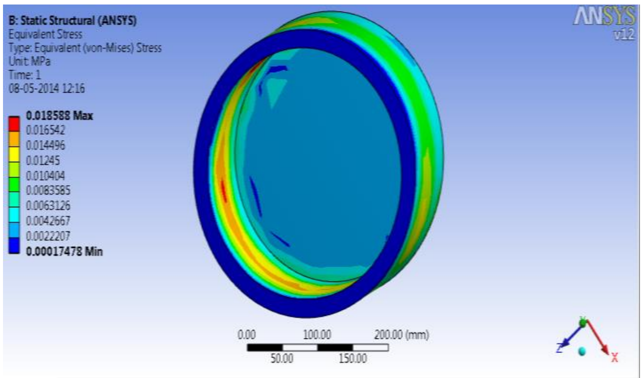

Fig. 12 Equivalent stress distributions on inner compacted cylinder wall

VI. CONCLUSION

Based on study of existing compactors, following conclusions can be drawn.

- As the garbage is to be compacted in the form of compacted cake, so the compactor is very much helpful in avoiding the spilling of loose garbage on streets.
- The analysis of proposed mechanism shows less deformation and stress generation, hence the complete compactor system is structurally stable.
- After the garbage gets compacted, it is portable for handling and recycling.
- The transportation cost may be reduced because of conversion of loose garbage in to compacted cake.
- As the garbage stored in compacted form, it requires less storage space.
- As the spilling of garbage on road gets reduced, the chances of health hazardous problems to human beings and animals may be reduced.

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