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DESIGN MODIFICATION OF A PORTABLE MANUAL HYDRAULIC WASTE COMPACTOR

Godfrey Ayeabu Sibete[1], Emomotimi Obonika Waratimi[2], Fortune Osaruchi Worgu[3]

[1]Department of Mechanical Engineering, Niger Delta University, Wilberforce Island, Bayelsa state, Nigeria.

[2]Nigerian Maritime Administration and Safety Agency Office: NIMASA CENTRAL ZONAL OFFICE, Warri, Delta State, Nigeria.

[3]Department of Mechanical Engineering, Rivers State University, Rivers States, Nigeria.

Corresponding Author: Godfrey Ayeabu Sibete

ABSTRACT

The waste compactor is a domestic waste management system which has attracted new research attention recently in applications like waste recycling and transportation of domestic wastes, As a sustainable and easy waste management method, It has become a direct substitute for reckless dumping and abandonment of excess waste. The hydraulic pressure waste compaction system is known to be working under the original idea of Newton's pressure law P = F/A. This project work however, presents an overview of the applications of P=F/A(Newton's Law of pressure) in a compaction system through hydraulic cylinder, and also analyses the design parameters in order to improve the compression ratio. The aim is to improve its value and enhance its applications in numerous fields such as hospitals, homes, schools and campuses and hence the practical demonstration of the dynamics of compaction to undergraduates. At the end of the project work, it was discovered that the hydraulic compaction system, possessed a great power for compression, capable of producing a 1:4 compression and even more to objects place in its bucket. The machine was also found out to be 75% efficient

Keywords: Design, Modification, Waste, Compactor, Waste compactor,Manual

1. INTRODUCTION

The world today is experiencing a continuous rise in the rate of waste generation and this is often associated with industrial and socioeconomic development. Some of these generated wastes are bio-degradable and will decompose naturally if left for a span of time while others may not fall into that category and in that case, has to be properly disposed or refined for use again through a process called recycling. In any of these cases, a proper management of these waste materials has to be considered. This necessitates a device which can effectively reduce the size of waste materials for waste to be disposed safely (Yerinmearede et al, 2020)

DEFINITION OF WASTE

Unwanted materials are derogatorily referred to as waste(s), because what is considered waste by one person may not be waste by another (i.e still useful to another person) hence, the term "waste" can be described as subjective and inaccurate (Adham Yasser et al, 2014). Nevertheless, in the context of this article and research, we will consider waste as been limited to already discarded non-biodegradable and bio-degradable house hold materials in their solid form. Such materials could include empty tin, aluminum cans, various forms of paper and nylons, plastic bottles, other forms of plastic materials, various forms of wooden materials, and clothe materials.

In a more generic sense, waste materials can be categorized into three based on the state of matter in which they exist. They are; solids waste, liquid wastes (sewages and the likes) and waste gases.

There are various wastes types considered by modern systems of waste management, they include;

Municipal waste: This includes the normal household waste, commercial waste and demolition waste.

Hazardous waste: this consist of industrial waste,

Biomedical waste; this consist of clinical waste generated from health care centers and hospitals,

Special Hazardous waste; this includes toxic and radioactive waste, corrosive or explosive waste and electronic waste.

Solid waste; these consist of garbage and refuse,

Sludge; which could be from waste water from plant water supply treatment or air contamination regulation installation in addition to other disposed materials like hard, fluid, semi-hard, either included gaseous substances developing from industrial, business, mining, agricultural processes and also from community activities but does not involve solid or domestic substances in home sewage, either solid, or dematerialized materials in domestic sewage or solid either dematerialized substances in irrigation return flows or industrial discharges.(nyichomba@udsm.ac.tz)

In the most basic setting, solid waste can be regarded as any discarded or disposed material. Some common illustrations of hard wastes comprise waste tyre, latex paints, garbage, scrap metal, appliances and vehicles, oil, void aerosol cans, paint cans, furniture and toys, compressed gas cylinders, fabrication and destruction debris etc.

It is important to sort between waste that still possess valuable useful material such as paper and paperboard, deposit beverage containers, clothing, hazardous waste etc. After the material sorting, it is taking to the plant which makes it possible to retrieve metal components in sorting mechanically, different types of wastes pressed together are packaged and buried in the landfill. For the aim of properly discarding hard wastes, there is the desire for a waste compactor that is mechanically operated. Hence, a waste compactor is a device utilized for the aim of volume compression or size reduction of solid waste material with the support of a mechanical action.

2. LITERATURE REVIEW

In this section we place our focus on reviewing important literature on the subject. Under this chapter, terms like history of compactors will be given preference followed by early and up to date development of compactors. Similarly, this chapter will specialize in the distinct works done by researchers on this very subject and deduce the gaps which will be found in their researches.

The employment of compactor as a means of waste management is not a new technology.

In a more generic perspective, the responsibility for waste management cannot be left for the citizens of a particular civilization but the governing council of that civilization. And this responsibility includes both the collection of waste and overseeing framework to protect the health and interest of its people and the environment (Perry, Juhlin & Normark, 2010). And healthy living conditions cannot be realized without the application of proper strategies in waste collection and disposal scheme (RushBrook & Pugh, 1999) (Ogwueleka, 2009).

In a research work conducted by Yuming et al (Guan, 2011) on vibrating compactor, it was concluded that vibratory motion in many cases resolves to an abnormal distribution of materials in the waste compact. In a journal published in January-February 2020 ISSN: 0193-4120 Page No. 8877 - 8888 8878 Published by: The Mattingley Publishing Co., Inc. we can see a new approach was taken into consideration based on a computer model designed and analyzed with finite element analysis (FEA) on ANSYS. (Jimoh, 2005) was able to look into the performance analysis aspect of waste management systems in which he discussed on various models as well as the accurate workload data that those models require for proper operation.

The most common motorized waste compacting systems utilized compressed air or inert gas (pneumatic systems) that are controlled by a manual or automatic solenoid valve that is able to give the necessary power in an affordable, flexible, and consistent manner, whereas electric motors and actuators cannot. The main advantage of this method is that the working fluid (air) is always available. Furthermore, the use of compressed air isn't limited by separation because it may be efficiently transported through channels. (Beer,Russel Johnson , DeWolf, & Mazurek, 2009). They are safer because the working fluid can be discarded without further processing after usage. Its restriction is that it necessitates the installation of air creating hardware. Compacted air must conform to institutionalized requirements, such as being dry, clean, and containing the fundamental grease for pneumatic gear. As a result, the formation of pneumatic frameworks is normally pricey due to hardware such as blowers, channels, lubrication cylinders, dryers, and controllers.

In contrast, the crank mechanism is linked to an electric motor. A turning crank generates a rotational movement that can be converted to a linear movement adopted for the necessary compression (Wagner & Singh Chatwal, 1997). The diameter of the crank mechanism defines the stroke. Furthermore, calculations are baffling when compared to the simple model. Another type of trash compactor is the Portable trash compactor (diagram 2.7) have a 'high-tech' design with a built-in cart to help with space and safety considerations. Typically, this style of compactor is placed in a utility area or main trash area. A built-in shopping cart (carrying a sturdy poly bag) collects compacted trash. When the compactor is full, simply roll the cart into the bin area and press a button, and the electric lift mechanism will start (garbage can be empty in the bin). The compactor can compact about 750 gallons of collapsing waste before it is empty (this equates to almost 4 cubic yards).

3. MATERIALS AND METHOD

For this project, adequate material selection was done in order to enhance efficient functionality of the project as shown in Table 1 below, the following factors are the key areas considered to enhance the functionality;

- Reliability.
- Complexity.
- Ductility.
- Tensile strength.

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- Resistance to corrosion.
- Available of materials.
- Machinability.

TABLE 1: TABLE SHOWING COMPONENTS, MATERIALS AND JUSTIFICATION.

S/N	Component	Material	Justification
1	Compactor frame	structural steel	Cheap, easily accessible and replaceable.
2	Cylinder	Alloy steel	Hardness and high resistance to buckling and compressive stresses.
3	Piston rod	Alloy steel	Hardness and high resistance to buckling stresses.
4	Compressing plate	Mild steel	Availability and easily replaceable and high strength.
5	Compactor bucket	Mild still and structural	Availability and easily replaceable and high strength and resistance to distortive stresses.

Drilling and welding operations are the major manufacturing processes that were adopted in this project. In general, the required dimension of the frame was cut out and assembled by welding. Also, angle-bars were cut to the required dimension, then welded together to produce a metal foundation; Step 1 involves fabricating the base frame, Step 2 involves fabricating the vertical part of the frame, Step3 involves fabricating the bucket, Step 4 involves fabricating the piston tray, Step 5 involves fitting the hydraulic cylinder into the frame.

4. DESIGN CALCULATIONS

$F = P \times Apist. \times {}^{\eta}vol$ (eqn. 3.1) for the force produced by piston.

$A = \frac{\pi}{4}D^2$ (eqn. 3.2) area of piston rod.

$D = \sqrt{\frac{4 \times F}{\pi \times P \times V_\eta}}$ (eqn. 3.3)

$Le = K \times L$ (eqn. 3.4)

Slenderness ratio calculations

$\lambda = \frac{4 \times Le}{d}$ (eqn. 3.5)

$\lambda_g = \pi\sqrt{\frac{E}{0.8 \times S_y}}$ (eqn. 3.6)

Safe loading calculation

$F = \frac{\pi^2 \times E \times l}{SF \times {L_K}^2}$ (eqn. 3.7) where E is modulus of expansion, l is length, SF is factor of safety.

$I = \frac{\pi D^4}{64}$ (eqn. 3.8) for the moment of inertia of the piston rod

$V = \frac{L}{t}$ (eqn. 3.9)

$\mathbf{V} = \frac{Q}{A}$ (eqn. 3.10)

$P_1A_1 = P_2A_2$ (eqn. 3.12)

$P_H = \frac{P_2 \times Q}{\eta_\eta}$ (eqn 3.13)

P = 50 bar

$\eta vol = 0.85$

Required force F = 15205.5 N

By substituting in equation 3.3

$Dp = \frac{4 \times 9810}{\pi \times 5000000 \times 0.85}$ = 6.7 cm, the closest standard value = 6.8 cm

DR = 3.6 cm.

$\phi = 1.49$

$\sigma = 415$ MPa.

E= 200 GPa

L = 140 cm

By substituting in equation 3.4

Le = 140*0.7 = 98 cm

By substituting in equation 3.5

$\lambda = \frac{4\times9.8}{3.6} = 108.9$

By substituting in equation 3.6

$\lambda_g = \pi\sqrt{(200 * 1000)/(0.8 * 415)}$ =77.1051

SF = 3

By substituting in equation 3.8

$I = \frac{\pi\times36^4}{64}$ = 82447.9576 mm4

By substituting in equation 3.7

$F = \frac{\pi^2\times E\times l}{SF\times {L_K}^2}$

5. RESULT AND DISCUSSION

This section shows the result of input and output data.

TABLE 2: INPUT AND OUTPUT RESULT

S/N	PARAMETER	Initial volume	Final volume	Total density	Total mass
1.	TIN	0.12705	0.00667m^3	494.76	3.3kg
2.	ALUMINIUM	0.12705	0.0033m^3	110	0.636kg
3.	PAPER	0.12705	0.03176m^3	322.2	10.25kg

It is important to note that the densities given by the experiment outcome is only related to the change in volume of the object due to compression and not the solid density of the objects.

6. CONCLUSION AND RECOMMENDATION

The need for a better way of handling domestic waste had led to a number of alternatives with their attendant teething high cost of operation and maintenance. However, in the future, if this technology is further developed and embraced, the cost of disposal, transportation and management of waste locally will drastically reduce as well as the improper disposal of wastes in the environment. A better development would be compactors that can handle a larger variety of wastes beyond domestic wastes, and to separate the waste automatically by computer aided means, sorting out ferro-magnetic materials from their category of materials through magnetism and can compact wastes at the end of the process, this advancement should be carried out in industrial scale so as to be able to process large amount of waste on daily bases to cater for the immense waste generation quotient.

In order to improve the conceptualization of the waste compactor, the following improvements can be made.

1. The compactor can be modified to first grind waste materials before compaction the compaction takes place.
2. Heat can be used to reshape materials before eviction from trunk hence the binding will be needless for certain kind of materials.

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