International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 794-803 www.ijaem.net ISSN: 2395-5252

Design and Construction of a Motorized Aluminium Can Compression Machine

Sylvester Emeka Abonyi[1], Obiora Nnaemeka Ezenwa[2], Christopher O Nwoye[3]

[1]Department of Electrical Engineering, Nnamdi Azikiwe University Awka, Anambra State, Nigeria
[2]Department of Mechanical Engineering, Nnamdi Azikiwe University Awka, Anambra State, Nigeria
[3]Department of Industrial and Production Engineering, Nnamdi Azikiwe University Awka, Anambra State Nigeria

Submitted: 10-10-2021 Revised: 19-10-2021 Accepted: 22-10-2021

ABSTRACT
This work is on the design and Construction of a Motorized Aluminum Can Compression Machine using an electric motor as the prime mover of the slider crank mechanism. The slider crank mechanism converts the rotary motion of the electric motor to linear motion of the Can compressor head. The compressor head was keyed a shaft. The shaft is actuated both on the compressing of the Cans and releasing it to fall into a bin collector. The crushing force needed to compress the Cans to reduce its volume was calculated. The designing of different parts of this Can Compressing Machine considered ergonomic factors for people that will use this machine to compress Cans. Different sizes of Can (8.4 oz. – 16 oz.) made of aluminum was used to run test on the machine. The result obtain indicates that the motorized Can compressing machine can reduce the size of a Can by 80% of the initial size.

Keywords: Motorized, Aluminum Can, Slider crank, Compression force.

I. INTRODUCTION

Pollution of our environment has been on the increase by different processes. The manufacturing industries package their products with aluminum Cans, hence aluminum Cans liter our environment by users of these products. To ensure that this aluminum Cans do not constitute hazard to our environment, there is need to device a means to eliminate them. Hence, a mechanical aluminum Can compression machine is basically one of the most helpful machines in this regard. It helps to prevent the Cans from polluting the environment, thus creating a better place to live in.

There are different processes available for compressing different materials such as printer cartridges and aluminum Cans for beverages. Soft drinks, beers, milk, etc. are available in lightweight materials. Aluminum Cans are simple to recycle at very lower cost than other materials.

Can Compression Machines are available in different types, sizes and speed, with different models. There are various methods by which different types of Can compressors are used to crush these Cans. Some compress the Can by pressing from both sides into itself, while some smash the Can from above. The two commonly used methods of compression are the pneumatic method by which the Cans are compressed by electrically powered machines, and the manual method by which the Cans are compressed by manually machines operated.

An intermediate capacity compressing machine that compresses one Can at a time was discovered by Morlock, 1986 and a similar concept was disclosed by Baumgartner, 1992. This machine comprises of a vertically oriented rotatable drum, which is an idler drum driven by the Can compressors, with a mounted compressor roller. The compressor roller, which is power driven and which drives the drum, is a metal cylindrical structure having ribs on the exterior positioned such that a nip is formed between the inner surface of the drum and the outer surface of the Can compressor, the nip being capable of opening against a resilient bias.

Binita et.al 2018 designed and fabricated a machine that is operated both manually and electrically. The machine uses a chain drive for transmission of power to compress cans. It also has a single hopper that loads can. This machine makes use of inversion of single slider crank mechanism and chain drive mechanism to achieve compression action.

Newman, 1984 invented another Can compressing device, the Can compressor was similar in most respects to the devices previously described but was provided with a slide guide that directs the Cans into the nip between the roller and the drum. The device suffers from aluminum galling problem previously discussed.

Bryan V. 2020 in his design ensured that Cans are compressed in a way that it eliminates the risk of cutting your fingers on a ragged edge though it doesn't compress Cans quickly. The Easy Pull makes it incredibly easy to crush Cans. It was designed to compress an average of 19 Cans per minute. The Easy Pull makes it incredibly easy to crush Cans.

This work developed a motorized aluminum Can compressor using a slider crank mechanism. It overcomes the problems of galling, and has features incorporated that work together to eliminate the tendency to jamming caused by fragments of Cans buildup. This design also incorporated the compressing of two Cans at a time.

II. MATERIAL SELECTION

Mild steel was selected for construction of the frame based on its properties. It is also known as carbon steel or plain carbon steel due to its composition of iron and carbon. It has an ultimate tensile strength of 440MPa and tensile yield strength of 370MPa, This property is especially desirable for construction due to its weldability and machinability. Its modulus of elasticity is 205GPa with bulk modulus of 140GPa.

2.1 Angle Iron

Mild steel is the least expensive material used in every type of product, it is wieldable. With its relatively low melting point, good fluidity, castability, excellent machinability, resistance to deformation and wear resistance, steels have become an engineering material with a wide range of applications and are used in pipes, machines and automotive industry parts, such as cylinder heads (declining usage), cylinder blocks and gearbox cases (declining usage). It is resistant to destruction and weakening by oxidation.

An angle iron (Fig.1) is a constructional material consisting of pieces of iron or steel with an L-shaped cross section, able to be bolted together (Oxford Languages dictionary). Structural steel angles have lots of dimensions to comply with different uses.

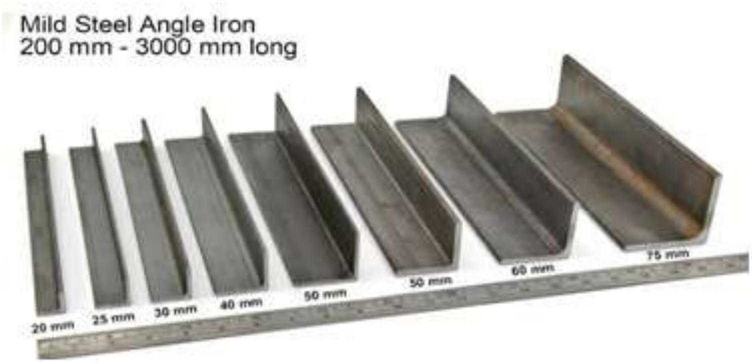

Fig.1 Different sizes of angle Iron

2.2. Electric Motor

Electric motor shown in Fig.2 is one of the components of the Can compression machine and runs on ac voltage. To convert thet circular motion to linear motion, mechanical attachments are added to the motor's shaft. This includes the fly wheel and the connecting rods.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 794-803 www.ijaem.net ISSN: 2395-5252

Figure 3.2. Cross sectional view of a 1hp Electric Motor

2.3 Flywheel

It is a circular high strength material that has a cylindrical opening to fit in into the shaft of the electric motor. This is different from some other types of flywheel with grooves in which a belt can grip on. This is a groove-less Flywheel which transmits motion directly from the electric motor to the connecting rods..

Figure 3. Flywheel

2.4 Connecting rod

This is a thin rod used to connect the flywheel to the square piston. It has an opening at both edges so that one can fit in to the square piston and the other to the flywheel. It is of a moderate strength and stiffness.

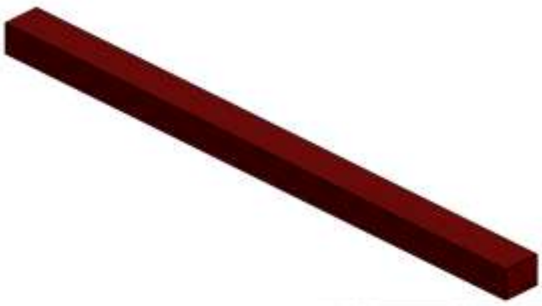

Figure. 4 Connecting rod

2.5. Square Piston

This unlike other pistons is made of a square shaped wooden material. It has a hole drilled in its centre to allow for a cylindrical metal rod to fit thereby adding to its weight. The square piston has a mass of about 3kg. A metallic grip is attached to this square piston with the aid of nails so that the connecting rod can attach to it.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 794-803 www.ijaem.net ISSN: 2395-5252

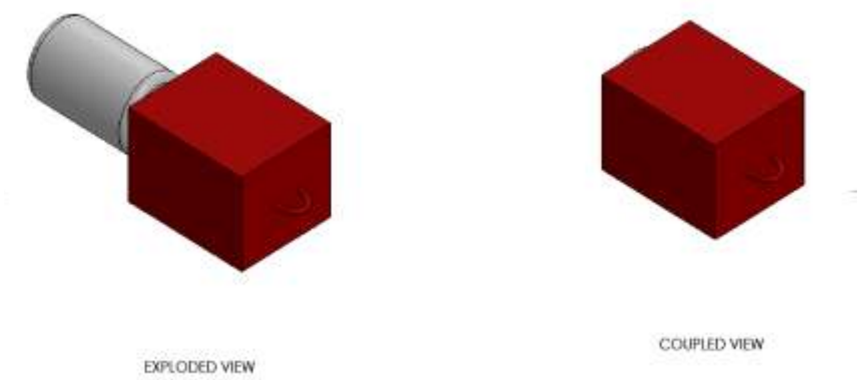

Figure 5 Square Piston

III. METHOD

3.1 Design analysis

The aluminum Can compression machine was designed using CAD software- solid works 2015 version. The motion synthesis, speed ratio, tensions, angle of contact was developed based on the design specifications. The total design work for this aluminum Can compression machine was split into two parts: System design and mechanical design.

3.2 System design

The system design of this machine mainly considered the following: Physical constraints and ergonomics, Space requirements, Arrangement of various components on main frame of system, Man-machine interactions, Number and position of controls, Working environment of machine, Chances of failure, Safety measures to be provided, Servicing aids and Ease of maintenance.

3.3 Mechanical design:

The mechanical design of this machine was done using CAD model. Fig. 6 shows the design of the Can compression machine.

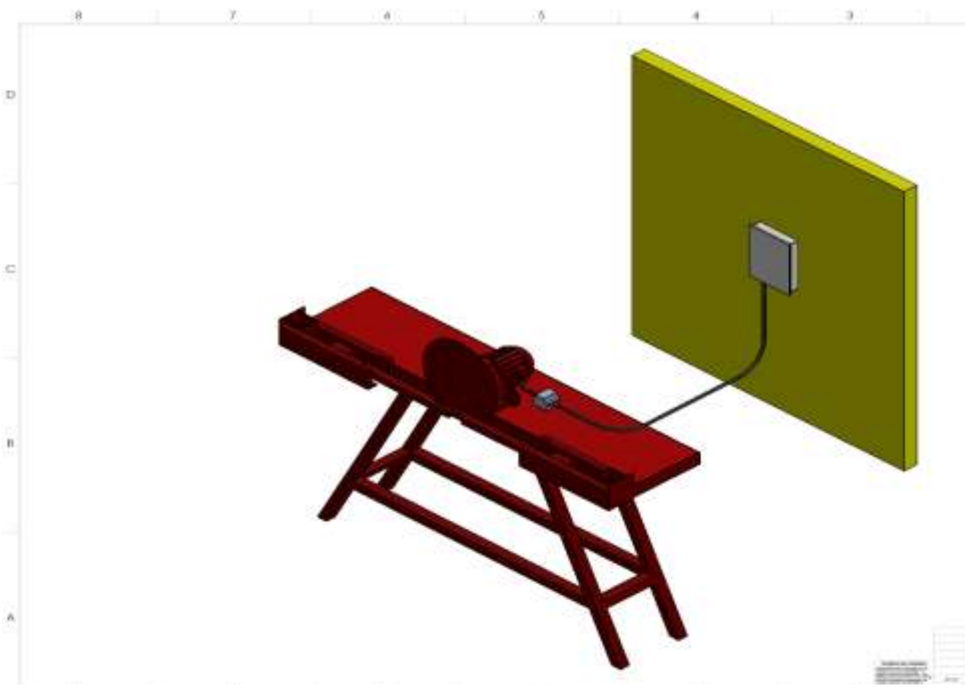

Figure.6 Model design of Motorized Aluminum Can compression

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 794-803 www.ijaem.net ISSN: 2395-5252

3.4 Design specifications

The designed Can compression machine consists of a sliding crank rod and piston box, a flywheel and an electric motor. The specifications are as follows:

- A low speed electric motor to power the machine
- Flywheel of diameter 31cm
- Connecting rod: Two Connecting Rods of 50cm each
- Piston (3kg): Two Square Box Piston of 6 ×6 × 12.5cm

3.5 Force analysis

According to Kittur R.A (2017) torque for the general system is given as

$$T = \frac{4500 \times HP}{2 \times \pi \times N} kg/m$$

Where T = Torque N/m, HP = Horse power P = Power Watt N = Peed of Pulley rpm

$$T = F \times r \times \sin\theta$$

Where F = Linear Force. $F \times r \times \sin\theta$

3.3.1. The tangential force of the crank rod.

The tangential force of the crank rod needed to slide one body against another is composed of adhesion and a deformation term. The behavior of a metal sliding on a metal is predominantly governed by the adhesion mechanism. Transfer of material from one surface to another supports this. The deformation term assumes a significant role when two materials differ greatly in hardness values, the normal force is high, and or the harder surface has a significant degree of roughness.

The tangential force of the crank rod is given as

$$F = \frac{T \times 2}{d} N$$

Where d = diameter

3.3.2. Connecting rod force (F_Q)

During each rotation of the flywheel, the connecting rod is often subjected to large and repetitive forces. The forces include shear forces due to angle between the piston and the crank rod end, compression forces as the piston moves downwards and tensile forces as the piston moves upwards.

The connecting rod force is given as

$$F_{QC} = F_{tc} \times \cos\theta \ N$$

Where F_{QC} = Connecting rod force F_{tc} = tangential force of connecting rod

3.3.3. Force along sliding

This can also be referred to as frictional force along sliding action of the piston which is connected to the connecting rod. It is the resistance created by any two objects when sliding against each other. This friction is also known as kinetic friction and is the force needed to keep the surface sliding along another surface.

$$F_S = F_{QC} \times \cos\theta \ N$$

Where F_S = Sliding force,

3.3.4. Force on piston.

To determine the force required to compress a can up to 80%, we consider the mass of the compressing piston (Binitaet.al, 2018).

Therefore, the mass of the wooden piston = 3kg

Diameter of the Can = 6cm

Height of the square piston (h) = 8cm

Therefore $F = m \times g$

Where: m= mass, g = acceleration due to gravity = 9.81m/s

= 3× 9.81 = 29.43N

Torque transmitted through the pulley

T = force × length of square piston

= 29.43×8.5 = 250.155 N/m

Power transmitted to compress the can

$$P = \frac{2\pi N_1 T}{60}$$

$$= \frac{2\pi \times 144 \times 250.155}{60}$$

$$= 3772.737W \quad = 3.772KW$$

IV. RESULTS

Different sizes of aluminum Cans used to package different beverages were compressed with the aluminum Can compression machine. The aluminum Cans compressed were used for beverages such as malt drinks, coke-cola drinks, energy drinks, beer drinks. The results obtained after compression were compared with that before compression.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 794-803 www.ijaem.net ISSN: 2395-5252

Table 1. Length of Cans before and after compression

S/N	Type of Cans	Length of Cans before compression (cm)	Length of Cans after compression (cm)
1	Malt drinks	11.4	1.8
2	Coke-Kola drink	13.5	1.4
3	Energy drinks	14.4	1.6
4	Beer drinks	15.9	2.3

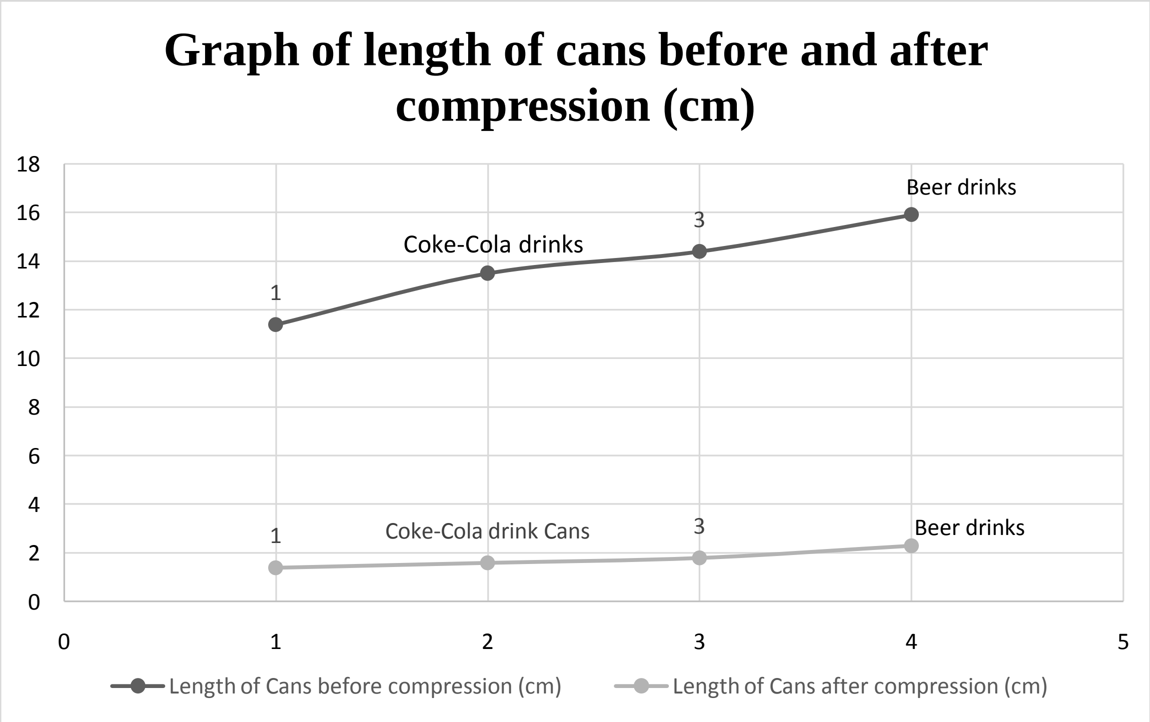

Fig. 1 Graph of length of cans before and after compression (cm).

Graph of fig.1 shows that the length of the Cans were reduced appreciatively after compression. For example the length of malt drink Can was 11.4cm before compression, but it was reduced to 1.8cm after compression. This indicates that the compression machine achieved a good result.

Table 2. Diameter of Cans before and after compression

S/N	Type of Cans	Diameter of Cans before compression (cm)	Diameter of Cans after compression (cm)
1	Coke-Cola drink	4.7	6.4
2	Energy drinks	5.5	6.6

3	Malt drinks	6.4	7
4	Beer drinks	6.8	7.5

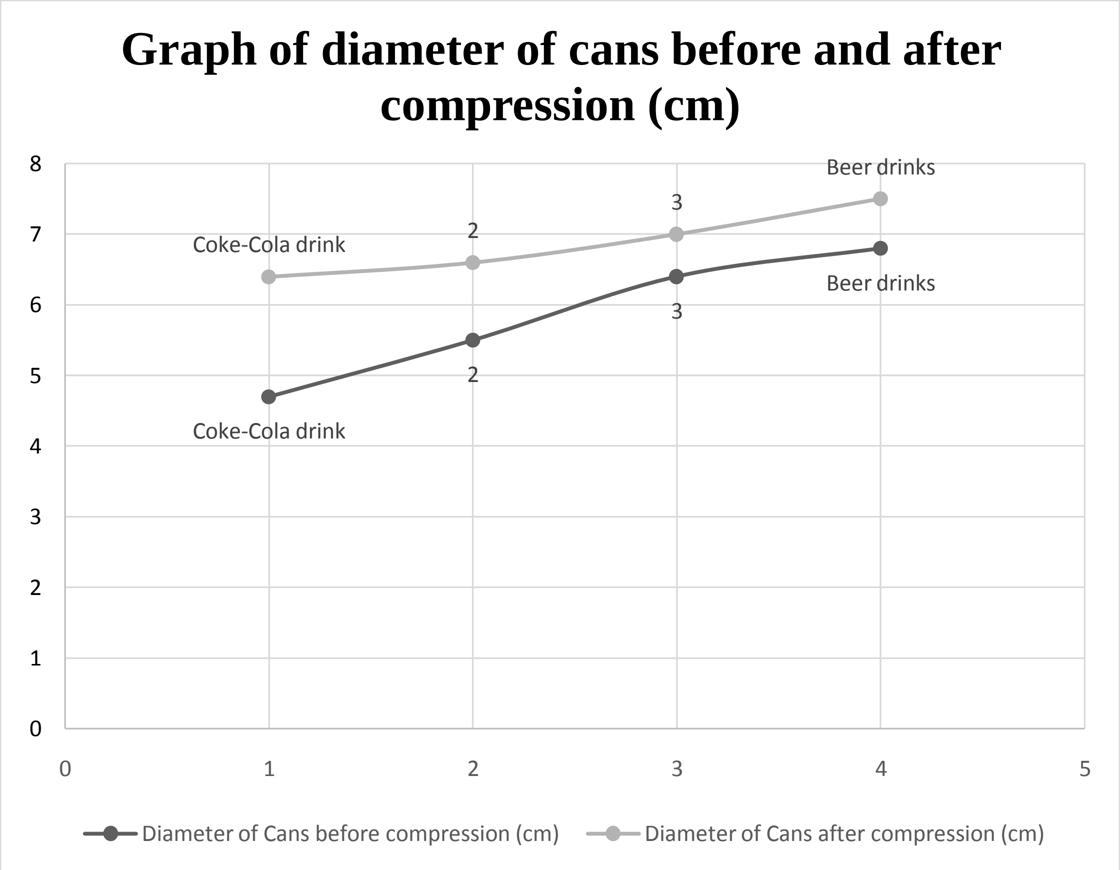

Fig.2 Graph of diameter of Cans before and after compression (cm)

Fig.2 shows the graph of diameter of Cans before and after compression (cm). The results obtained indicate an increase in the diameter of the Can after compression. This is minus to this compression machine.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 794-803 www.ijaem.net ISSN: 2395-5252

Table 3. Volume of Cans before and after compression

S/N	Type of Cans	Volume of Cans before compression (cm^3)	Volume of Cans after compression (cm^3)
1	Coke-Cola drink	234	45
2	Energy drinks	342	55
3	Malt drinks	367	69
4	Beer drink	577	102

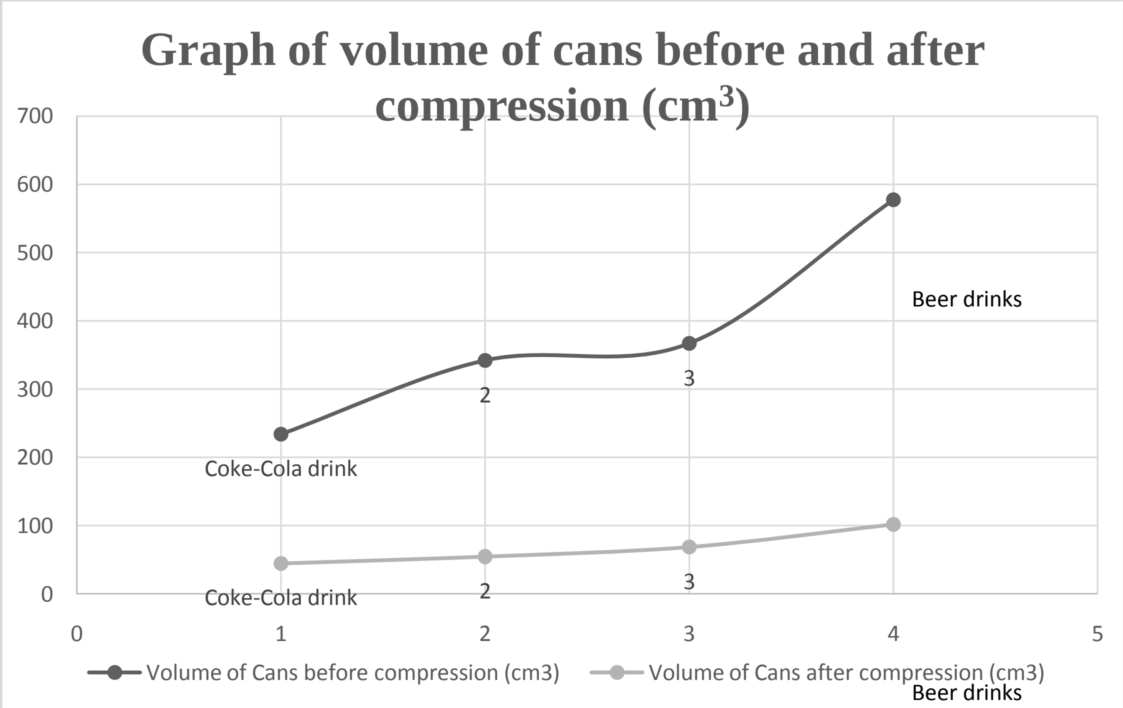

Fig.3 Graph of volume of cans before and after compression (cm^3)

Fig.3 shows the graph of volume of cans before and after compression. It indicated reduction in volume of the Cans. The volume was calculated using the formula;

$$\textbf{Volume of cans = area x length} = \frac{\pi d^2 L}{4}$$

Where d = diameter and L = length.

Table 4 Percentage (%) reduction in volume of cans

S/N	Type of Cans	Volume of Cans left after reduction (%)	Volume of Cans removed (%)
1	Energy drinks	16	84

2	Beer drinks	18	82
3	Malt drinks	19	81
4	Coke-Cola drinks	19	81

Table 5. Number of Cans compressed in seconds

Time (seconds)	No of Cans compressed
60	46
120	93
180	139
240	186
300	234

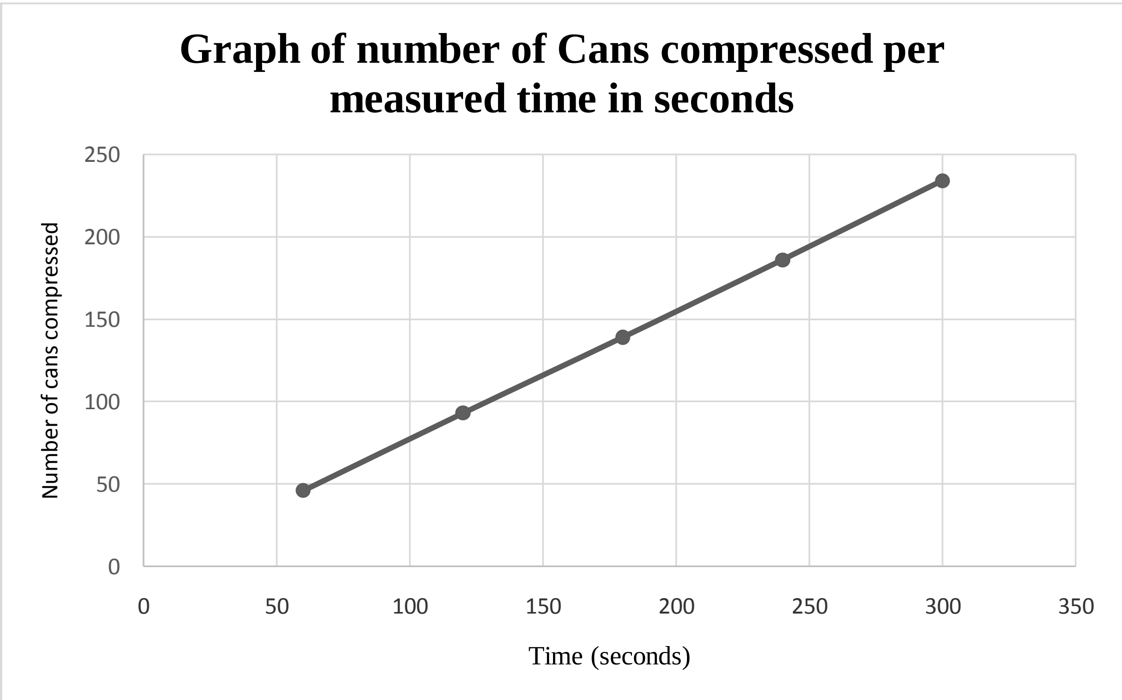

Fig. 4 Graph of number of Cans compressed per measured time in seconds

The graph of Fig. 4 shows of number of Cans compressed per seconds. This graph determines the efficacy of this compression machine. The percentage reduction in volume was calculated using the formulae;

$$\%\text{Volume of Cans left after reduction } = \frac{Volume\ of\ Cans\ left\ after\ compression}{Volume\ of\ Cans\ left\ abefore\ \ compression} \times 100$$

%Volume of Cans removed = 100−volume of Cans left after reduction

V. CONCLUSION

From the above results, we observe that there is a great output from this machine as regards the number of cans it can compress in a minute. The lengths of the different Cans considered achieved about 80% reductions from its initial size. This compression machine can compress different types of Cans with different diameters. It was also observed that the heavier the mass of the piston block the more the compression force, and the faster the compression process.

REFERENCES

[1]. Ajibola A. (2015). Recycling aluminum Cans; problems associated with improper disposal of Cans. Retrieved September 29, 2015fromhttps:blog.wecyclers.com/2015/09/29/recycling-aluminum-Cans-problems-associated-with-improper-disposal-of-aluminum-Cans

[2]. Cynthia H. (2020). Aluminum Can Compression machines, an important tool for your life. Retrieved January 3, 2020 from https:www.smarthomekstz.com/aluminum-Can-compression machines

[3]. Fracis C. Moon (2007). The machines of Leo de Vinci. Franz Releaux: Kinematics of machine from J. Renaissance to the 20th century. Springer science and media

[4]. Jeremy (2014) .what a Can compression machine is and how it works. Retrieved October 27, 2014, from https:dorecycling.com/blog/2014/20/27/what-is-Can-compression machine-how-it-works/

[5]. Kgosisele E. &Zhaohui L, "An Evaluation of Waste Management in Botswana: Achievements and Challenges" Journal of America Science, 2010.

[6]. Kittur R.A. (2017) design and force analysis of slider crank mechanism for film transport used in VFFS machine 4(12) pg. 41-47

[7]. Mbonu C, Nkwor C and Akaegeusi O (2014). Design and manufacture of cam and follower apparatus. (Unpublished degree theses) NnamdiAzikwe University Nigeria.

[8]. Muhammad, H.M.Z. (2008). Design of a recycle bin Can compression machine (unpublished diploma dissertation) University, Malaysia Pahang. Myszka, D. H. (2006). Machines and Mechanism: Kinematic Analysis (4th Edition). Boston: Princeton Hall.

[9]. R. Rajesh et al, Design and Fabrication of Can Compression machine, JIRSET, VOL.5, Issue 8, May 2016

[10]. R. S. Khurmi and J. K. Gupta (2017). First multi colour edition – Theory of Machines – Simple Mechanisms [A textbook for the students of B. E. / B. Tech., U.P.S.C. (Eng. Services); Section 'B' of A.M.I.E (I)]

[11]. R. S. Khurmi and J. K. Gupta (2017). First multi colour edition – Theory of Machines – Belts, Ropes and Chain Drives [A textbook for the students of B. E. / B. Tech., U.P.S.C. (Eng. Services); Section 'B' of A.M.I.E (I)]

[12]. Sager S.et.al (n.d) can crusher machine (unpublished degree thesis) GM institute of technology, Davangere

[13]. S.Shaikh (2021). Manual can crusher. Retrieved 2021 from https://www.academia.edu/6862397/manual_can_crusher

[14]. Shinde, Landge, biradar, S.M (2017). Design and fabrication of aluminum tincan crusher 5(6).39-44