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ECO PRESS: PNEUMATIC CYLINDER WASTE CRUSHER - WASTE MANAGEMENT SOLUTION

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ABSTRACT

The growth of the restaurant industry in Saudi Arabia has been remarkable in recent years. However, this growth brings a significant need to adopt sustainable practices that can minimize the environmental impact of these establishments. One key area where restaurants can focus their efforts is waste materials compression projects, which can have a significant impact on reducing their ecological footprint and positively affecting the environment. In this paper, a preliminary design of pneumatic cylinder can crusher is proposed as an effective method to make the disposing of waste process in Saudi Arabia's restaurants smother. The proposed pneumatic cylinder can crusher consists of components designed according to available standards. Preliminary calculation of the force needed to crush the can was also conducted. The proposed system could be tested both through prototype testing and actual testing. By charging the air compressor to its maximum capacity, the machine managed to compress four cans in 48 seconds.

Keywords: Waste Materials Compression, Pneumatic Cylinder, Can Crashers

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1. INTRODUCTION

The growth of the restaurant industry in Saudi Arabia has been remarkable in recent years. However, this growth brings a significant need to adopt sustainable practices that can minimize the environmental impact of these establishments. One key area where restaurants can focus their efforts is waste materials compression projects, which can have a significant impact on reducing their ecological footprint and positively affecting the environment.

Restaurants generate large amounts of waste, including food waste, packaging materials, and single-use items. This waste not only occupies valuable landfill space but also contributes to pollution and the depletion of natural resources. By implementing waste materials compression projects, restaurants can effectively reduce the volume of waste generated, leading to several environmental benefits [[1]]

Waste materials compression projects can also contribute to efficient waste management practices in the restaurant industry. By compacting waste materials, restaurants can optimize the use of space in waste disposal areas, reducing the frequency of waste collection and the associated transportation emissions. This leads to cost savings and a more efficient waste management system, benefiting both the environment and the restaurant's bottom line. The impact of waste materials compression projects extends beyond individual restaurants themselves, since it can inspire other businesses, both within and outside the food and beverage industry, to adopt similar waste reduction practices. This collective effort can lead to a broader movement towards sustainable waste management in Saudi Arabia [[2]].

The problem of waste encompasses a range of environmental, social, and economic issues associated with the generation, management, and disposal of various types of waste materials. One of the primary issues is the sheer volume of waste being generated in restaurant industry. As the number of restaurants in Saudi Arabia is significantly increasing, the amount of waste produced continues to increase, straining waste management systems [[3]]. In addition, a significant portion of waste materials, including plastics, paper, glass, and electronics is not recycled. This leads to the depletion of natural resources and increased environmental pollution [[4]]. Moreover, the processes of managing and disposing waste are typically expensive for the government. It often requires significant financial resources for waste collection, transportation and treatment.

Saudi Vision 2030, launched in 2016, is an ambitious and comprehensive roadmap for the Kingdom of Saudi Arabia's future development across various sectors. While the primary focus is on economic diversification, social development, and cultural transformation, the vision also incorporates environmental sustainability as a crucial element ([5]). Several key aspects of Saudi Vision 2030 align with the ultimate goal of protecting the environment: First of all, there is an increasing emphasis on adopting the principles of circular economy, which involve reducing, reusing, and recycling materials to minimize waste [[6]]. Also, the vision includes plans for "Green Saudi Arabia" and "Green Middle East," which involve extensive afforestation and reforestation projects [[7]]. Moreover, the vision emphasizes the importance of raising public awareness about environmental issues and promoting environmental education. By addressing these environmental considerations, Saudi Vision 2030 aims to create a more sustainable and balanced approach to development, aligning economic growth with environmental conservation [[7]]. As the vision progresses, ongoing efforts will likely be made to ensure that environmental sustainability remains a core component of Saudi Arabia's development strategy. The proposed system aligns with these initiatives, since it reinforces environmental sustainability through minimizing the amount of waste and restaurants and facilitating efforts of disposing it [[8]].

A wide range of materials can be recycled, and the specific materials accepted for recycling can vary. Implementing waste materials compression initiatives in restaurants yields several advantages for both the companies and the environment. These programs effectively decrease the amount of waste generated, maximize the use of resources, minimize carbon emissions, provide cost savings, improve reputation, assure compliance with regulations, involve employees, and support environmental conservation through the implementation of such initiatives, restaurants may significantly contribute to the establishment of a sustainable future, characterized by the reduction of waste, the effective utilization of resources, and the preservation of the environment for future generations [[9]].

The current study focuses on designing a can crusher, a device used for crushing aluminum cans to reduce their size. This makes the cans easier to store and transport for recycling or disposal. There are several mechanisms that can be implemented to achieve the desired outcome. First, power screw is a mechanism that is used to convert rotary motion to liner motion. This is achieved by using a screw and a nut figure 2. When the screw is rotated, the threads engage with the matching threads on the nut to move along the length of the screw. This mechanism is widely used because it can amplify small forces into larger ones, making it easier to lift heavy loads, press, or secure objects [[8]] Another option is gear mechanism, a system that transmits power and motion between rotating shafts using gears. When one gear (the driver) rotates, its teeth engage with the teeth of another gear (the driven gear), causing the second gear to turn figure 3. This mechanism can change the speed, torque, and direction of the mechanical energy in a machine. Another potential mechanism is press mechanism, which is a type of mechanism that uses force to shape, form, or cut materials by pressing down on them. This mechanism can be powered by mechanical, hydraulic, or pneumatic means.

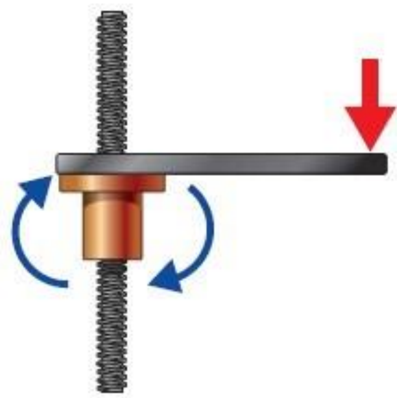


Figure 1 : Power screw mechanism [[10]]

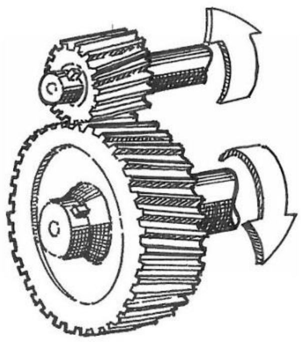


Figure 2 : Gears mechanism [[11]]

Waste crushers can be categorized into four types. The first type is manual waste crashers, which are simple devices that require human effort to crush cans. They are typically used in home kitchens and small-scale recycling operations. The second type is electric waste crashers, which use an electric motor to crush cans automatically. They are more powerful and efficient than manual crushers and are suitable for high-volume can crushing. The third type is hydraulic waste crashers, which use hydraulic pressure to crush cans. They are typically larger and more powerful than other types of crushers, making them suitable for heavy-duty industrial applications. Lastly, a pneumatic cylinder can crusher is a type of a crushing machine that uses the power of compressed air to crush aluminum cans. This type of can crusher is commonly found in industrial and commercial settings, such as recycling centers, manufacturing facilities, and food service establishments. Using a pneumatic cylinder for the purpose of the current study has several advantages, the majority of which were sated in [[7]]. For instance, Pneumatic cylinder can crushers are highly efficient and can crush cans quickly and consistently. This makes them suitable for applications where large volumes of cans need to be processed in a short amount of time. Also, many pneumatic crushers have a compact design, making them suitable for installation in small spaces or on production lines where space is limited. Moreover, pneumatic crushers provide consistent and uniform crushing results, ensuring that cans are uniformly flattened or compacted. In addition, Pneumatic systems offer precise control over the crushing process. Operators can adjust the pressure and timing to achieve the desired level of crushing, which can be important in certain applications. On the other hand, implementing waste materials compression initiatives may pose certain disadvantages. Pneumatic systems require regular maintenance to ensure they function correctly, and this includes maintaining the air compressor and checking for air leaks in the pneumatic circuit([12]) In addition, pneumatic crushers rely on a source of compressed air, typically provided by an air compressor. If the air compressor fails or there are issues with the air supply, the crusher may not function. Finally, some pneumatic cylinder can crushers can be noisy during operation, which may be a concern in residential areas. Table 1 shows pneumatic cylinder standards.

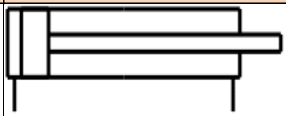
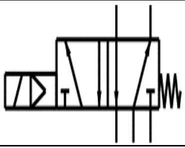
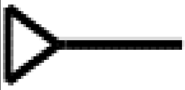
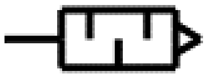
Table 1: Pneumatic Cylinder Standards

Cylinder C	Cylinder C 245 DE 63MM Dia 200MM stroke
Key selector valve	Key selector valve 5/2 way.
Silencer/Muffler	Silencer/Muffler 1/8".
Straight Male	Straight Male 10MM-8MM X 3/8"-1/4"-1/8".
Y Union	Y Union 8MM.
Tubing Blue	Tubing Blue 10MM X 6.5MM
Cylinder Linear	Cylinder Linear DNC 32 Bore 25 Dia

2. DETAILED DESIGN

Pneumatic cylinder uses the compressed gas to produce force to move the piston in liner motion. The main piston moves vertically and compresses the can. After that, a smaller piston moves horizontally to push the can out. A double-acting cylinder is a type of hydraulic or pneumatic actuator commonly used in various industrial applications to perform mechanical work [[10]]. It has two distinct modes of operation: When hydraulic or pneumatic pressure is applied to the rod end of the cylinder, it pushes the piston and rod outward, extending the cylinder to perform work in one direction. When pressure is applied to the opposite side of the cylinder, known as the cap end, it pushes the piston and rod back in the opposite direction, allowing it to perform work in the other direction. Table 2 demonstrates the components of a pneumatic circuit. Also, figure 3 shows the diagram for the pneumatic circuit.

Table 2: Components of pneumatic circuit

Component	Descriptions	Diagram
Cylinder	Double acting cylinder	
Valves	used to control the flow of compressed air within the circuit	
Compressor	responsible for taking in ambient air and compressing it to a higher pressure	
Silencer	Used to reduce the noise generated by the release of compressed air	

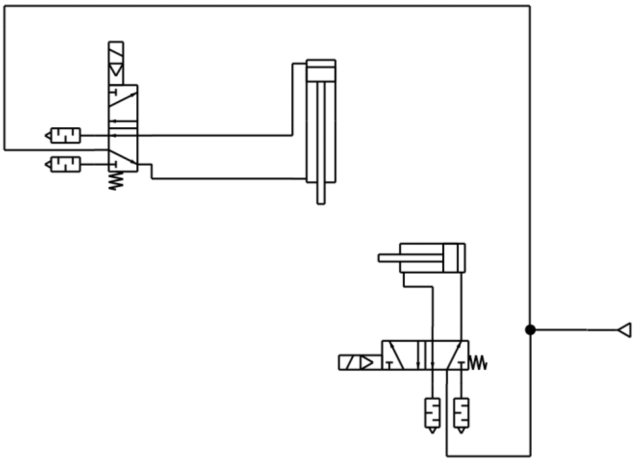


Figure 3: Pneumatic circuit using SMCDraw software

Table 3 demonstrates the two operations of penumatic cylinder, whereas Table 4 demonstrates the dimensions of the cans to be crashed.

Table 3: The Two Operations of Pneumatic Cylinder

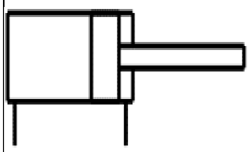
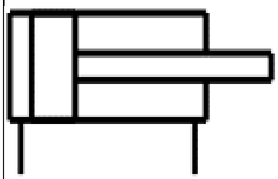
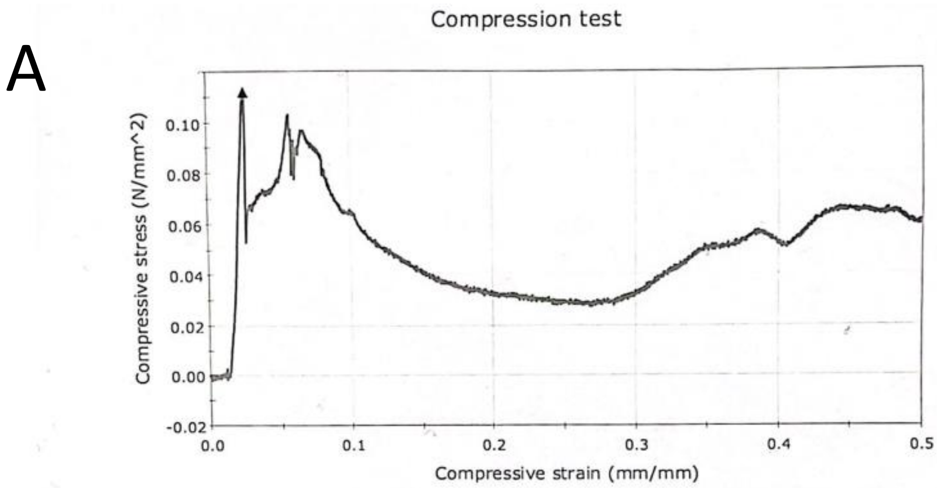
Piston position	Descriptions	Diagram
Extension	When pneumatic pressure is applied to the rod end of the cylinder, it pushes the piston and rod outward, extending the cylinder to perform work in one direction	
Retraction	When pressure is applied to the opposite side of the cylinder, known as the cap end, it pushes the piston and rod back in the opposite direction, allowing it to perform work in the other direction	

Table 4: Measurements of Various Cans

Cans	Length	Diameter	Thickness	Volume
Pepsi Type 1	112mm	67mm	2.62mm	320 ml
Pepsi Type 2	131mm	50mm	2.54mm	220 ml
Ice Tea	112mm	67mm	2.62mm	310 ml

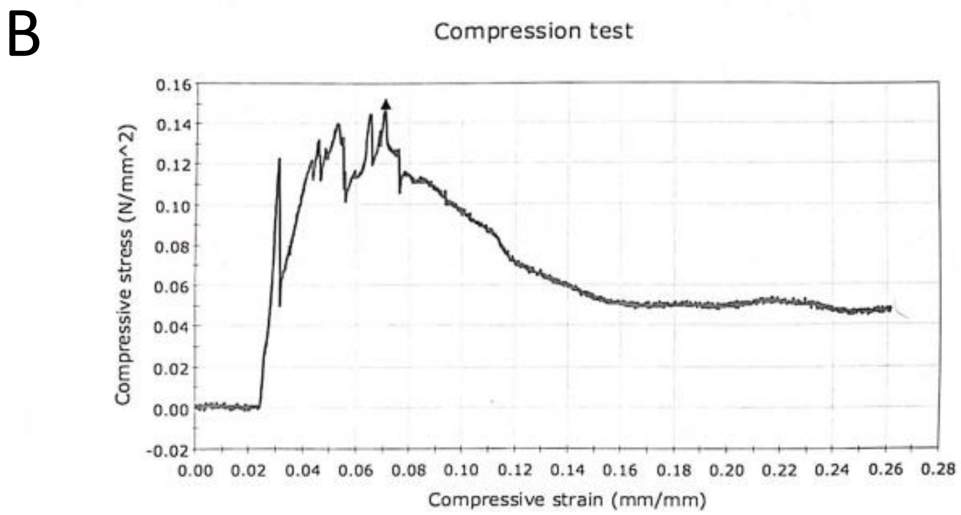
To get the crushing force needed, a compression test was conducted using a Instron universal testing machine shown in figure 4. The results of the test on type 1 Pepsi cans are displayed in figure 5 (a), whereas the results of the test on type 2 Pepsi cans are displayed in figure 5 (b). According to these results the compressive force (buckling force) is 390N.

Figure 4: Instron Testing Machine



	Compressive load (kN)	Compressive strain (mm/mm)	Compressive stress (N/mm^2)	Modulus (Automatic) (N/mm^2)
1	0.39	0.03	0.11	11.86

Tested specimens: 1



	Compressive load (kN)	Compressive strain (mm/mm)	Compressive stress (N/mm^2)	Modulus (Automatic) (N/mm^2)
1	0.39	0.03	0.18	19.40
2	0.32	0.07	0.15	2.65

Tested specimens: 2

Figure 5: (a) Results of the compression test for type 1 and (b) results of the compression test for type 2

The compressive force needed to crush the can is 390N. 400N was selected to ensure the crushing of the can. To calculate the pressure needed, Equation 1 was used.

$$P = \frac{F}{A} \qquad \text{Equation (1)}$$

And for the extension phase, Equation 2 was used.

$$A = \frac{\pi}{4} D^2 \qquad \text{Equation ([13])}$$

On the other hand, for the retraction phase, Equation 3 was used.

$$A = \frac{\pi}{4} (D^2 - d^2) \qquad \text{Equation ([14])}$$

P is the pressure and F is the force, the compressive force is 400N and the maximum pressure that the Compressor can provide is 8 bars, while D is 63mm and d is 20mm Which are the diameters for the actuator. Substituting in the equation resulted in:

$$A = \frac{\pi}{4} (63 \times 10^{-3})^2 = 3.117 \times 10^{-3} m^2$$

$$A = \frac{\pi}{4} ((63 \times 10^{-3})^2 - (20 \times 10^{-3})^2) = 2.803 \times 10^{-3} m^2$$

To calculate the force if 8 bars, which is the maximum pressure, are used, the compressor can output will be:

$$F = P \times A$$

For the extension phase:

$$F = 8 \times 10^5 \times 3.117 \times 10^{-3} = 2493.6N$$

For the retraction phase:

$$F = 8 \times 10^5 \times 2.803 \times 10^{-3} = 2242.4N$$

These forces are high, and what is needed is 400N, so the pressure needed would be calculated.

For the extension phase:

$$P = \frac{F}{A} = \frac{400}{3.117 \times 10^{-3}} = 1.28328\ bar \approx 2bar$$

For the retraction phase:

$$P = \frac{F}{A} = \frac{400}{2.803 \times 10^{-3}} = 1.42704\ bar \approx 2bar$$

The pressure needed for each phase would be 2 bars.

Figure 6 illustrates the compressing time needed for crashing different numbers of cans when using an air compressor of 50 liters. As the capacity of the air compressor increases, the number of cans increases and the compressing time required decreases.

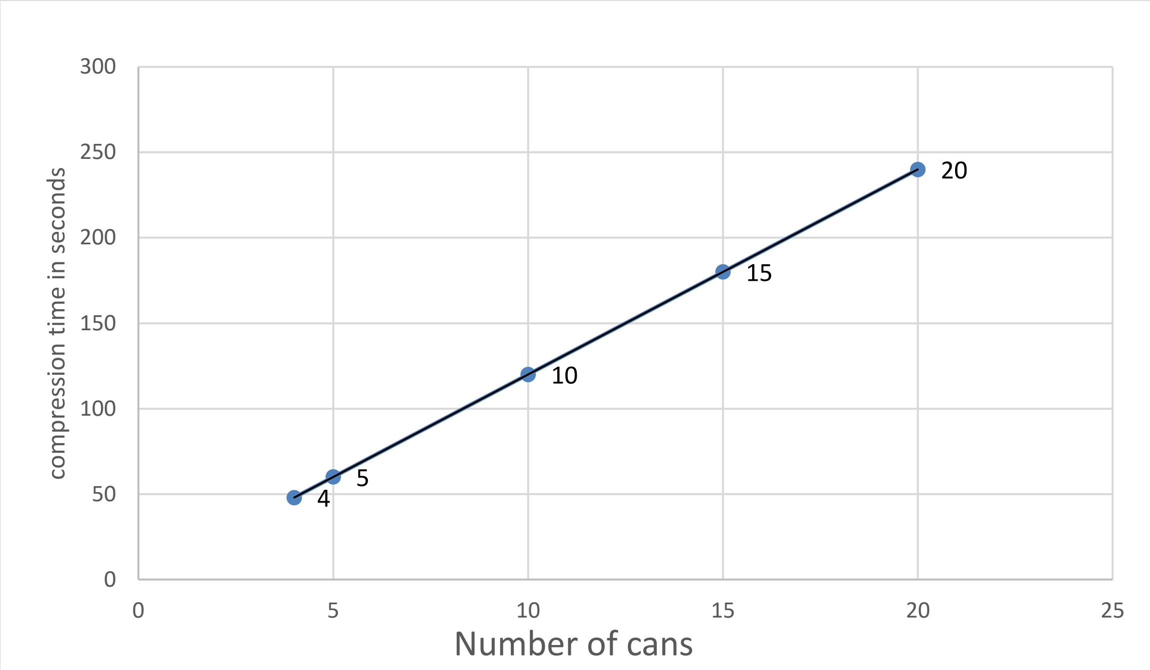


Figure 6: The required compressing time for crashing different numbers of cans using a 50-litre air compressor

3. PROPOSED PLAN FOR MANUFACTURING AND TESTING

The main components for manufacturing the pneumatic circuit are air compressor Edon silent white 50L 1Head figure 7, cylinder C 245 DE 63MM Dia 200mm stroke figure 8, cylinder Linear DNC 32 Bore 25, two Key selector valve 5/2 way. 1/4 FNPT Ports (Figure 9), two Straight Male 10mm X 3/8" figure 10, five Straight Male 10mm X 1/4", two Straight Male 8mm X 1/4", two Straight Male 8mm X 1/8), four Silencer/Muffler 1/8", Y Union 8mm, Tubing Blue 10mm X 6.5mm, and Tubing Blue 8mm X 5mm .

Figure 7: Air compressor used in the project

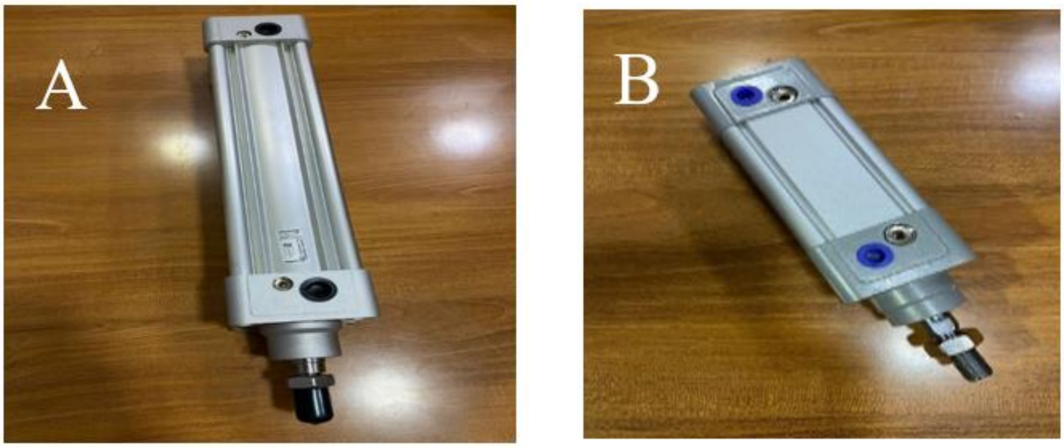


Figure 8: (a) The Main Cylinder and (b) the second cylinder

Figure 9: The two Key selector

Figure 10: The Sraights and Y Union

A base for the pipe and the system was made for manufacturing purposes figure 11. The researchers utilized a 3D printer (CR-10S Pro CREALITY printer) for their project. This revolutionary technique has completely transformed the way researchers materialize their ideas, enabling researchers to fabricate practical prototypes that showcase the potential influence of their innovations [[14]] For this project, a 3D printer was used for printing the parts for the frame as a prototype figure 12. Using a 3D printer to create parts offers several advantages, such as increased design flexibility, reduced waste, and potentially lower costs for certain projects. It allows for the creation of complex and intricate designs that might be challenging or expensive to produce using traditional manufacturing methods.

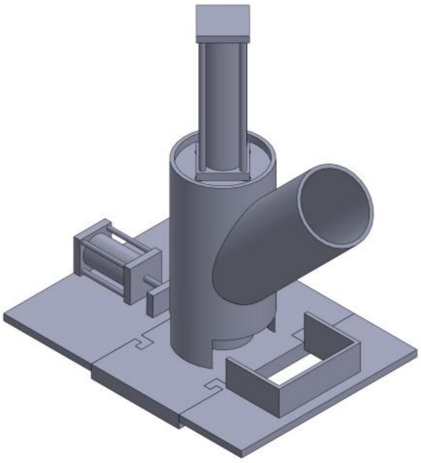


Figure 11: Overview of the project using SolidWorks software

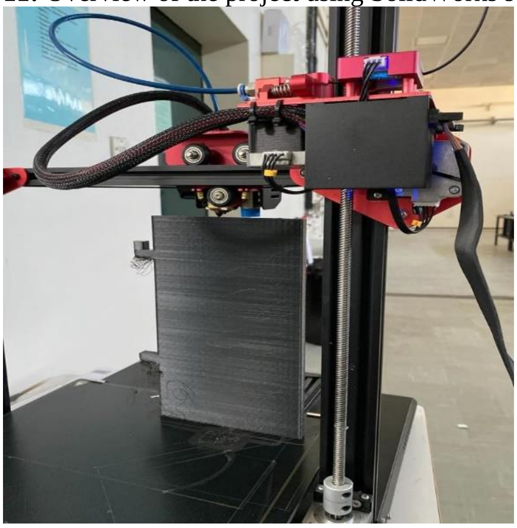


Figure 12: CR-10S Pro CREALITY printer used

Six distinct components were produced with the 3D printer in the project. The choice to employ 3D printing technology for these components was chosen because of its several benefits, such as its design adaptability, cost efficiency, and streamlined production. Nevertheless, it is crucial to acknowledge that the printing procedure for each component is expected to require extended periods of time, with an approximate length of up to 72 hours per part [[15]] The length of time is mostly determined by the intricacy and sophistication of the designs and the required level of accuracy. Figure 13 shows the prototype produced by the 3D printing, and it took the researchers 8 days and a half to complete printing this prototype.

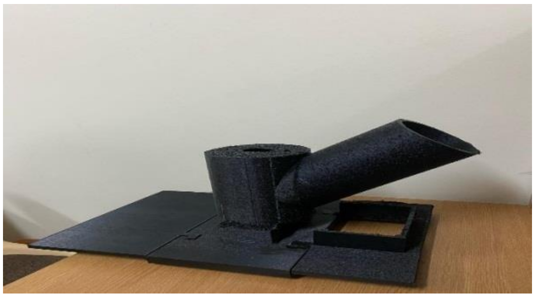


Figure 13: The portotype produced by the 3D printing

After finishing the prototype and close examination, the researchers decided to adjust the designee to make it easier for future maintenance and to reduce the vibration. Therefore, the researchers decided to add a removable plate to connect the pipe and the base. In this way, it will be easier to remove the parts and preform any maintenance procedure. The second adjustment will be the angle between the two pipes; it will be 35° instead of 45° to ensure a smother slip for the can. With the adjustment on the designee, the manufacturing of the model started. The first part is the plate between the piston and the pipe to attach them together using the laser cutting machine shown in figure 14. The second part is attachment at the end of the piston rod that will crush the can using the plasma cutting machine shown in figure 15.

Figure 14: The laser cutting machine and the plate between the piston and the pipe

Figure 15: The plasma cutting machine and the attachment at the end of the piston

The pipe fitting process, which involves cutting the two pipes so that they can be attached and welded together, involves several steps. First, a straight line is drawn on the table and the pipe is placed so that the line goes through the center of the pipe. Then another line is drawn with an angle of 35° with the first line and the second pipe is placed on the second line.

Then, the distance between the two pipes is measured and, based on that, lines are drawn on the pipes where the cutting will be done so that the two pipes can be fitted together. After that, cutting the pipes starts using cutting by gas machine. Figure 16 illustrates the different phases of the pipe fitting process: (a) as straight line is drawn to keep the pipe fixed, (b) a 35 angel is stretched from a straight line, (c) straight lines are drawn and the pipes are fixed at the predetermined angels, (d) the two distances are measured and it is ensured that they are identical, (e) a line is drawn based on the measured distances, and finally (f) the cutting is made based on the sloped point.

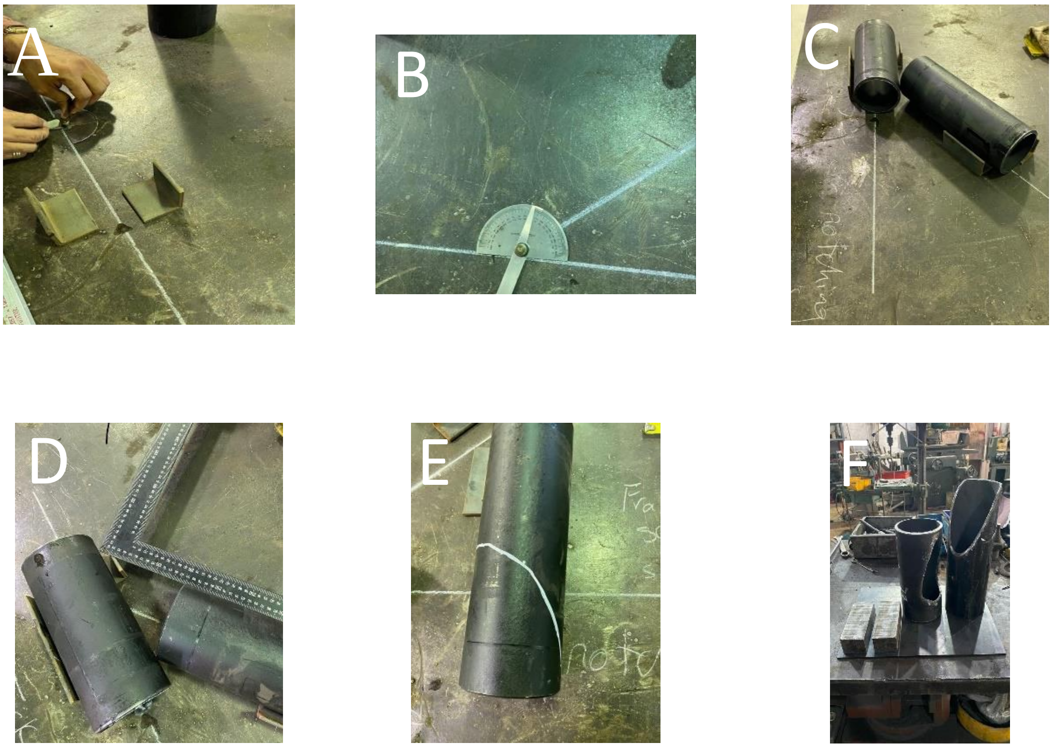


Figure 16: The differnet phases of the pipe fitting process

After that, the base plate to hold the pipes is cut using a laser cutting machine. Then, the removable plates that connect the pipe and the base plate are made. For this step, using proper screws for the plates and the drilled holes in them should be carefully chosen. After that, the threading of the holes is made. Then, bases for the main plate, one at each corner and the last below where the pressing will be, are made. The threading process that aims at allowing the nail to enter is illustrated in figure 17 (a), whereas the nail (b) was successfully entered after the threading process was completed. A saw machine is used to cut these bases.

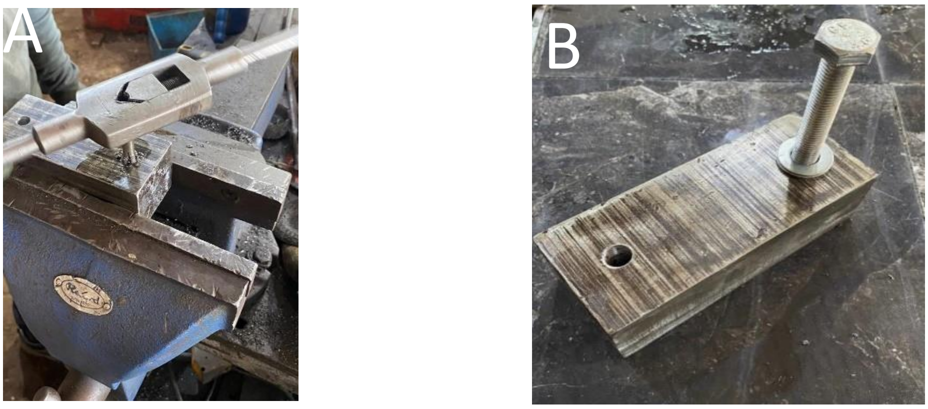


Figure 17: (a) Threading tool and (b) the nail

Finally, all parts were assembled and polished before welding. The polishing was done by Surface Prep: ensuring pristine surfaces for optimal adhesion, Priming Strategy: tailoring primers for superior corrosion resistance, Paint Selection: choosing quality paints for long-lasting results, Application Technique: employing precision for even coverage, especially around welded areas, Drying and Curing Methods: following manufacturer guidelines for maximum effectiveness, Inspection Protocol: meticulously checking for imperfections and addressing them promptly, and Quality Assurance Standards: verifying coating meets stringent quality benchmarks. After that, welding the different parts was done using gas metal for welding. Figure 18 shows the different parts before welding. Figure 19 shows the final shape after the five bases were fixed. Finally, figure 20 shows (a) grinding before welding and (b) the final shape after the whole welding process is complete.

Figure 18: Separate parts before welding

Figure 19: The final shape after the five bases were fixed

Figure 20: (a) Grinding before welding, and (b) the final shape after the whole welding process is complete

Several painting techniques were used. These techniques included (i) Surface Prep to ensuring pristine surfaces for optimal adhesion, (ii) Priming Strategy to tailor primers for superior corrosion resistance, (iii) Paint Selection to choosing quality paints for long-lasting results, (iv) Application Technique to employ precision for even coverage, especially around welded areas, (v) Drying and Curing Methods to Follow manufacturer guidelines for maximum effectiveness, (vi) Inspection Protocol to meticulously check for imperfections and address them promptly, and (vii) Quality Assurance Standards to verify that coating meets stringent quality benchmarks. Figure 21 shows: (a) the shape after painting, (b) the shape after sanding, and (c) the final shape after the painting was dried via entering the machine into the oven. Figure 22 shows the final shape of the eco Press: pneumatic cylinder waste crusher

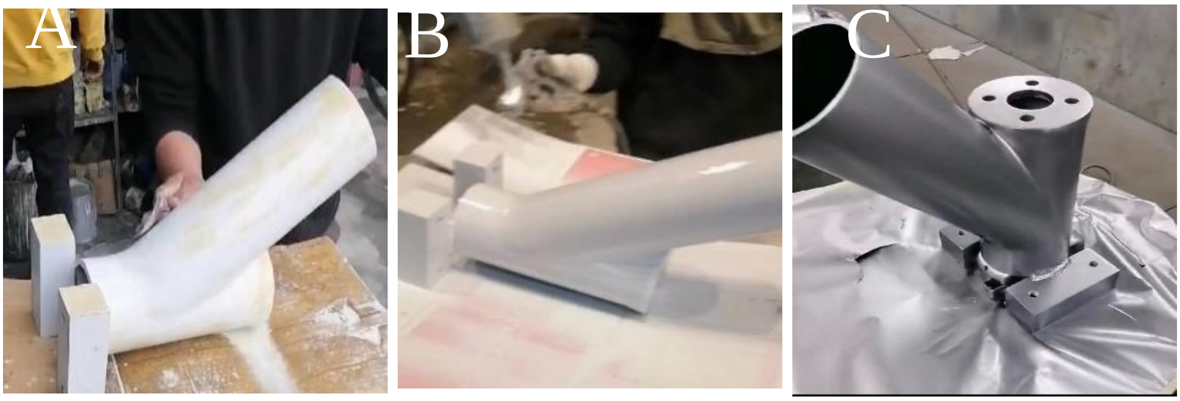


Figure 21: (a) the shape after painting bases, (b) the shape after sanding, and (c) the final shape after the painting was dried via entering the machine into the oven

Figure 22: Eco Press: pneumatic cylinder waste crusher

To build up the can crusher using pneumatic system, the components that need to be purchased include two pneumatic cylinders, valves, silencer and two pipes. In addition, there is a cost for labor work and some Miscellaneous parts if needed. Table 5 describes the materials needed to build up the system and the approximate price for each material. Finally, Figure 23 shows the final shape of the proposed system.

Table 5: Estimated costs

Type	Quantity	Subtotal SAR
Compressor	1	655
pneumatic cylinder 1	1	588.5
pneumatic cylinders 2	1	299
Key selector valve	2	460
Silencer	4	27.6
Straight Males	11	73.6
Y Union	1	9.2
Tubing	17	108.68
Printer Filament	2	260
Manufacturing cost		800
Total amount		3281.58

Figure 23: The Final shape of the proposed system

4. CONCLUSION

Implementing waste material compression initiatives in restaurants may yield several advantages for both the companies and the environment. Some of these advantages are waste reduction, optimal resource allocation, reduction of carbon footprint, cost efficiency and environmental conservation. In this study, a can crusher was designed using pneumatic system. Several comparisons were made to determine the materials and the components that serve the project goals. A pneumatic circuit was designed and the parameters required were calculated. Two types of cans were chosen for their size to be reduced by the can crusher. The crushing force and the pressure needed were calculated and the components were chosen to satisfy this calculation. SolidWorks software was used to design and draw the parts of the project. The proposed system could be tested both through prototype testing and actual testing. First, a prototype was made using 3D printer. This helped determine if the cans were crushed probably, and if the system was stable enough during the process. After assembling the model, it was tested. The results of the test showed that by charging the air compressor to its maximum capacity, the machine managed to compress four cans in 48 seconds.

The can crusher is expected to reduce the size of a can to make it easier to dispose. A pneumatic piston can be used to crush the can which is relatively easy to get. With that, the proposed system will minimize the cost while making it comfortable. The real-life model may not work efficiently under certain theoretical calculation. This might be caused by few factors, including the fact that not all cans are ideal in production and air Pressure Fluctuations. Also, pneumatic systems can be sensitive to temperature changes. Finally, if the components of the crusher are not properly aligned, it can lead to inefficient crushing.

REFERENCES

[1] Bharucha, J. (2018). Tackling the challenges of reducing and managing food waste in Mumbai restaurants. British Food Journal, 120(3), 639–649. https://doi.org/10.1108/bfj-06-2017-0324

[2] Khan, H. U., Husain, T., & Khan, S. M. (1987). Solid waste management practices in the eastern province of Saudi Arabia. Environmental Management (New York), 11(6), 729–734. https://doi.org/10.1007/bf01867240

[3] Rindfleisch, A., O'Hern, M., & Sachdev, V. (2017). The digital revolution, 3D printing, and innovation as data. Journal of Product Innovation Management, 34(5), 681–690. https://doi.org/10.1111/jpim.12402

[4] Gardner, L., Cruise, R. B., Sok, C. P., Krishnan, K., & Santos, J. M. D. (2007). Life-cycle costing of metallic structures. Proceedings of ICE. Engineering Sustainability/Proceedings of the Institution of Civil Engineers. Engineering Sustainability, 160(4), 167–177. https://doi.org/10.1680/ensu.2007.160.4.167

[5] Elhassan, R. M. (2021). Potential Opportunities for Waste to Energy and Recycling in the Kingdom of Saudi Arabia. IEEE Conference Publications, 76–81. https://doi.org/10.1109/icrega50506.2021.9388300

[6] Chakule, R. R., Patil, S., & Talmale, P. (2020). Design and development of can crushing machine. Asian Journal of Engineering and Applied Technology, 9(1), 25–28. https://doi.org/10.51983/ajeat-2020.9.1.1082

[7] Ouda, O. K. M., Peterson, H. P., Rehan, M., Sadef, Y., Alghazo, J., & Nizami, A. (2017). A Case Study of Sustainable Construction Waste Management in Saudi Arabia. Waste and Biomass Valorization, 9(12), 2541–2555. https://doi.org/10.1007/s12649-017-0174-9

[8] Bme, M. S. A., Rahman, M. A., & Hossain, D. (2022, September 19). Construction and performance test of pneumatic can crusher. http://suspace.su.edu.bd/handle/123456789/425

[9] Baker, M., PhD. (2024, March 25). Hydraulic vs. Pneumatic vs. Electric Actuators. yorkpmh. https://yorkpmh.com/resources/hydraulic-vs-pneumatic-vs-electric-actuators/

[10] Bello, S., Bajela, G. G., Lamidi, S., & Oshinlaja, S. (2020). Design and fabrication of pneumatic can crushing machine. International Journal of Advances in Scientific Research and Engineering, 06(10), 154–161. https://doi.org/10.31695/ijasre.2020.33914

[11] Cynnal, D.-. C. (n.d.). Design and technology. http://resource.download.wjec.co.uk.s3.amazonaws.com/vtc/2016-17/16-17_1-4/website/category/4/functions_of_mechanical_devices/mechanical_systems_and_movement/index.html

[12] Afrouzi, H. N., Yee, L. H., Annuar, K. a. M., Zaid, Z. B., Ghani, Z. A., Halim, M. F. M. A., Abidin, A. F. Z., & Shah, M. B. N. (2019). Development of an automatic can crusher using programmable logic controller. International Journal of Electrical and Computer Engineering (Yogyakarta), 9(3), 1795. https://doi.org/10.11591/ijece.v9i3.pp1795-1804

[13] ASTM Standards and ASME B36.19M Stainless Steel Grade Pipe/ tube. (n.d.). https://www.triloksteel.com/astm-standards.html

[14] Information about Saudi Green Initiative. (n.d.). Saudi & Middle East Green Initiatives. https://www.greeninitiatives.gov.sa/about-sgi/

[15] RS PRO ISO Standard Cylinder - 63mm bore, 200mm stroke, Double acting. (n.d.). RS Components Malta. https://mt.rsdelivers.com/product/rs-pro/rs-pro-iso-standard-cylinder-63mm-bore-200mm/1761649

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