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# Recycling of Waste Polyethylene Terephthalate (PET) into Insulating Wall Panels for Building Industry

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**Abstract** The administration and management of waste is one of the major issues confronting the advanced society and is not fairly constrained to plastics. The squandering or waste generated annually is by and large a claim in Pakistan. Reusing plastic is required to support the environment. The wall panels that are utilized in interiors are made up of Polyvinyl chloride (PVC) which is harmful and there are few chances to diminish the poisons from it. Moreover, they are not perfect insulators and are very expensive. The work aims to utilize plastic squander into wall panels made of reusing Polyethylene Terephthalate (PET) which are aesthetically pleasing, economical, easy to maintain and of high quality. The method incorporates case studies and surveys to find out the finest manufacturing and fabricating process. The experiment phased in product specification along with drawings, rendering, prototyping and finally recycling plastic into the final product. The conductivity of the material is raised by using blisters with a silver coating which raised from 5% to 10% and a vacuum is also created between the panels. The compressive strength is tested which is 80.5 MPa. If the product is made on a large scale, it will help in reducing plastic waste.

**Keywords** Recycling, Plastic Waste, Polyethylene Terephthalate (PET), Insulation, Wall Panel, Building

## 1. Introduction

Plastic waste is radically expanding day by day, because plastic does not break down naturally and plastic waste is relentlessly expanding. Almost 79 percent of the plastic ever made has finished up dumped, hardly being crushed, reused or recycled. Most of this plastic waste clogging conduits and landfills is because of single-use things like bottles, straws, packages, and cutlery. An expanding waste of plastic is contaminating the environment particularly marine life where the foremost of plastic is dumped. The waste plastic also harms water plants and water species. It is decimating the magnificence of nature and making the lives of water animals miserable. The plastic waste does not permit fish to breathe in new and clean water. The fishes inevitably swallow plastic waste and die unnaturally. Recently in the Philippines, a whale died due to disposable plastic. The environmental group found 40kg of plastic in its stomach having plastic bottles and grocery bags. The expanding rate of waste which is filling natural available places requires a worldwide consideration to seek inventive economical mechanical applications that add to the valuable developmental exercises [1, 2].

### 1.1. Project Description

Reusing plastics waste is one strategy for decreasing municipal squandering. The reuse of plastic bottles is a

challenge because of its non-degradable nature [3, 4]. Since the plastic does not break down naturally, the amount of plastic waste in our environment is relentlessly expanding. The development specialists warn that the reutilization of present products is required for the progress in the industry because of scarce resources. Reused plastic can be valuable if encouraged to make useful products i.e. insulating panels for walls. A water impenetrable wall panel framework can be made by using waste plastic which can be aesthetical, functional, and economical [5, 6, 7]. Insulating wall panels are made through reused sheets to supply cover in rooms. These are insides components which upgrade the excellence of the room with that of insulation. It increments the insulating quality with extra blisters and diminishes the plastic squander. The divulgence proposes a plastic-containing carrier for a beautiful wall or floor panel [8, 9, 10]. Kamal and Rizvi studied the recycling of waste PET bottles into low-cost alternative composite material [11].

### 1.2. Need of the Project

The plastic waste management is a challenge because of its non-degradability. Out of 8.3 billion metric tons of total waste, 6.3 billion metric tons is plastic and only 9% is being reused annually [5, 12, 13]. The rest is dumped and thrown away as garbage litter. Pakistan is also facing the problem of dumping plastic waste which is also essential to maintain the environment. The point behind working on this project is also to improve and recognize the changes coming in marine life as well as to secure the ocean animals [1, 2]. The reuse is also essential to secure and maintain the present resources for our future generation, especially to invest resources into new inventions and products.

### 1.3. Objectives of the Research

The objectives of the study are:

To recycle plastic into wall panels.

To manufacture wall panels from recycled plastic with insulating ability in rooms.

To manufacture wall panels from recycled plastic with aesthetic appeal.

### 1.4. Objectives of the Research

How to reuse (plastic) Polyethylene Terephthalate (PET) into panels?

How the PET recycled panels can be used as a cover to provide insulation when used on walls?

Which tests should be used for the conductivity and compressive strength of recycled PET wall panels against ordinary wall panels?

## 2. Materials and Methods

This is an experimental study to recycle plastic into wall panels and to utilize them as thermal insulation in rooms. The study is based on the preliminary research on inquiring case studies, literature review, market surveys and strategies, and secondly on experimentation and testing.

### 2.1. Case Studies

The research related to reusing and manufacturing of waste plastic products were studied to collect data and information which was available through local and international case studies. The two case studies which were considered most relevant are given as below:

Local case studies: Astoria grand tea trolley

International case studies: -Vega Serving Trolley

### 2.2. Surveys

The information about methods of recycling of PET into yarn and fabric was done to collect data about the reuse of plastic and fabrication process at ATS Manufactured and ECO plastic industries at Kahna, Pakistan.

The testing of the material was done in Polymer lab UET, Lahore.

### 2.3. Literature for Project

The project research started with background knowledge about plastic contamination. The project was studied also by keeping in view the effect on environment. Library books, daily papers, articles, and webs also had been the accommodating source of data in this task. A few websites are studied which had given detailed information about the plastic waste created in the world. Moreover, the most related book names are given below:

Ghaffar A. and Scott, G., Polymer Blends-I

F.N. Cogswell, Polymer Melt Rheology helps a lot to understand how to recycle plastic [13, 14, 15].

### 2.4 Target Audience

There is two basic segregation of target audience:

#### 2.4.1. Direct Target Audience

The direct target audience is waste recycling companies which are fundamentally working on plastic waste to diminish or to oversee it.

#### 2.4.2. Indirect Target Audience

The indirect target audience is individuals of all classes since the items made from reusing would be cost-effective and quality as well.

### 2.5. Product Specifications

#### 2.5.1. Material

Plastic that is used for recycling and making the wall

panels is PET (Polyethylene Terephthalate). It is regarded as an excellent material for many applications. It has excellent impact and tensile strength.

2.5.2. Theme

The theme of the panels was based on wavy, curvy, rounded patterns that were generated from the waves and ripples from the ocean. The design of the panels was 3D that can be felt by touching or seeing.

# 3. Product Manufacturing

### 3.1. Prerequisites for Making Product Consideration of Ergonomics

Ergonomics or human factor was also considered to make the product more functional and human friendly and to reduce the chance of damage or hurt.

### 3.2. Two Dimension (2-D) Drawings

After the selection of the final design, its size, dimensions, and features were finalized by making a technical drawing in 2 Dimension (2D) which helped in making an accurate and proportionate on Auto CAD.

### 3.3. Three Dimension (3-D) Drawings

The technical drawings were made in 3-Dimensions (3D) to evaluate how it will look like and what is the appropriate color for it. It makes an inventive view of the item with its highlights. Software utilized in creating these 3D drawings were made on 3DS MAX (Fig. 1a, 1b).

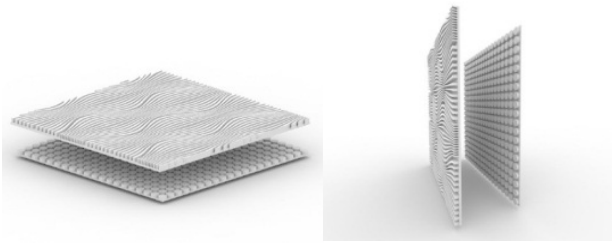

**Figure 1.** Three dimensions (3-D) drawings of the panels

### 3.4. Environmental Renders

Environmental renders were made additionally on 3DS MAX to evaluate the original placement in the interior environment (Fig. 2).

**Figure 2.** Use of wall panels in the interior

### 3.5. Prototyping and Die for Wall Panels

The die for panels manufacturing was made up of Medium Density Fiberboard (MDF). It was effortlessly accessible material and low price. It was made by utilizing a computer numerical control (CNC) router (machine), a cutting machine for perfect cuts (Fig. 3).

**Figure 3.** The prototype of the wall panel

### 3.6. Recycling of PET

Despite expanding investigation endeavors, it isn't however prudent to partition the wide assortment of plastics that end up within the squander stream. The perfect is streams of single, clean, and homogeneous recyclates, which show small specialized exertion for reusing [15, 16, 17]. A normal reusing course for squandering plastics can be part of two sorts of processes, one physical or mechanical treatment to plan and homogenize the squander, and the second dissolving.

### 3.7. Collection of PET Bottles

The primary step for the recycling process was continuously collecting the plastic material to be reused. The material was collected from shops and restaurants.

#### 3.7.1. Sorting

The plastic waste was collected and arranged in huge junk containers (canisters). Machines were used to sort out plastics into distinctive regions based upon a huge number of properties that were regularly demonstrated by the researcher.

#### 3.7.2. Washing

Washing was required to evacuate soil and buildups within the squander plastic. The standards were the same as those connected to any household washing. Thermal methods were used to dry the plastic in hot air.

#### 3.7.3. Size Reduction

The plastic was reduced in size by the two-stage process; in the primary stage, a shredder was employed to convert large particles into small ones of approximate size of 25-50 mm. Later, the chipping by rotational cutters was used in the second stage.

#### 3.7.4. Sheet Manufacturing

The recycled PET is at that point dried for some time recently reintroduction as a manufacturing material or before further processing. Dissolve sifting can advance decontaminate fabric through the evacuation of any non-melting contaminants which will have survived prior steps. Expelled material passes through an arrangement of screens to make pellets whereas non-melted particulate is blocked. Pelletized plastic gives a uniform-sized fabric that can be reintroduced into the manufacturing process.

### 3.8. Processing Technique

The diverse process and techniques were used such as casting, infusion molding, blow molding, compression molding, expulsion molding, and thermoforming to induce the desired item.

#### 3.8.1. Mold Making

There are various designs which can be made with vacuum shaping. The most innovative way to use vacuum shaping is to require any small thing, duplicate it numerous times, and after that vacuum for the modern design to make a more cohesive frame. The vacuum shaping makes a difference when it ties the individual pieces together and makes one form out of numerous pieces [18, 19]. The mold was made by employing a CNC machine and a CAD program. Drilling has drained the mold to form a vacuum that sucks air to shape the specified item. The mold was made by employing a CNC machine and a CAD program. Drilling has drained the mold to form a vacuum that sucks air to shape the specified item.

#### 3.8.2. Vacuum Forming

Vacuum shaping was used where a sheet of plastic was warmed to a melting temperature, extended onto a single-surface form, and constrained against the shape by a vacuum (Fig. 4). Vacuum shaping is utilized to create many different items from thermoplastic sheets. These incorporate enclosures, packaging, helmets, and showers

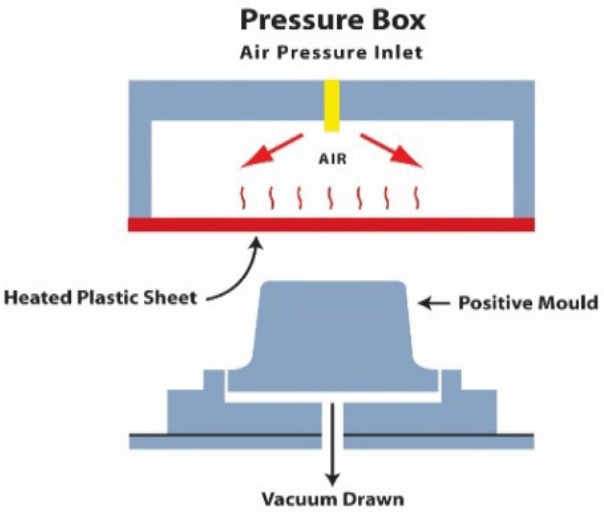


**Figure 4.** Vacuum shaping in wall panels

#### 3.8.3. Finishing

The item was cut out of the sheet by squeezing an edge through the item into a die underneath. Generally, it is a clean way of evacuating vacuum shaped parts from the material sheet [20]. It did not require an extraordinary cutting device to be made. The blisters were made by making little punch sheets through the vacuum shaping method. The vacuum was made within the blisters so that no heat can pass through it. It had increased insulation and compressive quality [21].

**Figure 5.** Final model and display of the wall panels

## 4. Conclusions

The plastic squander can be decreased by reusing

plastic in such way, whose rack life is high so that nothing needs to be disposed of after a short time. It can be recycled into distinctive items such as wall panels by this the environment can be safe and free of discarded items. This experimental research was conducted, in which the Polyethylene Terephthalate (PET) was reused and converted into wall panels with the equality of insulation and low cost. The study was based on the preliminary research on inquiring case studies, literature, market strategies, and secondly on experimentation and testing. The target audience was waste recycling companies and individuals of all classes who would use the recycled products. PET is selected because of its tensile strength. The theme of the panels was based on wavy, curvy, rounded patterns that were inspired by the waves and ripples from the ocean. The design of the panels was 3D (three dimensional) that can be felt by touching or seeing. The ergonomics points were considered to improve the design. The method incorporates case studies and surveys. The experiment was phased on product specification along with 2D and 3D drawings, rendering, prototyping and finally recycling plastic into the final product.

The material for making die was chosen as Medium Density Fiberboard (MDF) sheet because of its accessibility and low cost. The die was made by CNC cutting. The PET waste was collected, cleaned, and homogenized by its types by machines which sorted out plastics into distinctive regions based upon several properties. Washing is required to evacuate any soil and buildups on the squander. The size of the cleaned PET was reduced by a shredder to convert large particles into approximately 25-50 mm and then converted into sheets or fabric. The methods such as casting, infusion molding, blow molding, compression molding, expulsion molding, and thermoforming were used to induce the desired item and finally thermoforming was used.

The Guillotining of the item was done by cutting the item out of the sheet or by squeezing it from an edge. Blisters were moreover made by making little punch sheets through a vacuum shaping method. The vacuum was made within the blisters so that no heat can pass through it which increased the insulation and compressive quality [21]. 3D divider boards were used which give protection quality with the style to the product. The product was having insulation quality because of the vacuum in between the sheets so that heat cannot pass through it. It was waterproof, durable, long-lasting, and having a compressive strength of 80.5MPa. The thermal conductivity was also raised by the use of blisters coated with silver. If the product is made on a large scale it shall be helpful in reducing plastic waste.

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## REFERENCES

[1] M. R. Oliveira, M. Luz Garcia, A. C. M. Castro and T. N. Silva, Mortar with pet - Preliminary results. Energy Reports, Vol 6, 800-803, 2020.

[2] A. Mohammadinia, Y. C. Wong, A. Arulrajah and Horpibulsuk. Strength Evaluation of Utilizing Recycled Plastic Waste and Recycled Crushed Glass In Concrete Footpaths. Construction and Building Materials, 197, 489-496, 2019.

[3] D. V. Marques, R. L. Barcelos, H. R. T. Silva, P. Egert, G. O. Parma, E. Girotto, and R. F. Magnago. Recycled polyethylene terephthalate-based boards for thermal-acoustic insulation. Journal of Cleaner Production, 189, 251-262, 2018.

[4] Q. Zuo, W. Leonard and E. E. MaloneBeach. Integrating performance-based design in beginning interior design education: an interactive dialog between the built environment and its context. Design Studies, 31(3), 268-287, 2010.

[5] P. O. Awoyera and A. Adesina. Plastic wastes to construction products: Status, limitations and future perspective. Case Studies in Construction Materials, 12, 328-330, 2020.

[6] N. Horton, S. Patel and S. Lubowinski. Impervious Wall Panel. U.S. Patent Application 16/356,073, Filed July 11; 2019.

[7] E. Kosior and J. Mitchell. Current Industry Position on Plastic Production and Recycling. in Plastic Waste and Recycling. Academic Press, 133-162, 2020.

[8] R. Kassab. Experimental study and development of sustainable sandwich panels, Ph. D. Thesis, 2020.

[9] H. J. Hannig. Plastic-containing carrier for a decorated wall or floor panel and method for producing the same. U.S. Patent Application 16/474,746, filed October 17, 2019.

[10] J. Brandrup, M. Bittner, W. Michaeli and G. Menges. Recycling and recovery of plastics. Hanser Verlag; 1996.

[11] M. Arif Kamal, S. J. Rizvi. The recycling of waste PET Bottles as a low-cost alternative composite material International Journal of Design and Manufacturing Technologies, 2(1), 2008.

[12] M. Lee. Recycling polymer waste. Chem Brit, 7, 515-516; 1995.

[13] C. Ingrao, A. L. Giudice, C. Tricase, R. Rana, C. Mbohwa and V. Siracusa. Recycled-PET fiber based panels for building thermal insulation: environmental impact and improvement potential assessment for a greener production. Science of the total environment, 493, 914-929, 2014.

[14] S. Chowdhury, A. T. Maniar and O. Suganya. Polyethylene terephthalate (PET) waste as building solution. International Journal of Chemical Environmental and Biological Sciences. (IJCEBS). 1(2), 308-312, 2013.

[15] Hopewell J, Dvorak R, and Kosior E. Plastics recycling: challenges and opportunities. Philosophical Transactions of the Royal Society B: Biological Sciences, 2009; 364(1526), 2115-2126.

[16] G. Iannace and G. Ciaburro. Modelling sound absorption properties for recycled polyethylene terephthalate-based material using Gaussian regression. Building Acoustics, 1351010X20933132; 2020.

[17] M. K. Urbikain. Energy efficient solutions for retrofitting a residential multi-storey building with vacuum insulation panels and low-E windows in two European climates. Journal of Cleaner Production, Vol. 121, pp. 459, 2020.

[18] T. Vivier and M. Xanthos. Peroxide modification of a multicomponent polymer blend with potential applications in recycling. Journal of applied polymer science, 54(5), 569-575, 1994.

[19] C. S. Ha, H. D. Park and W. J. Cho. Recycling of commingled plastics by cellulosic reinforcement. Journal of applied polymer science, 74(6), 1531-1538, 1999.

[20] D. Yang, B. Zhang, Y. Yang, Z. Fang, G. Sun and Z. Feng. Morphology and properties of blends of polypropylene with ethylene-propylene rubber. Polymer Engineering & Science, 24(8), 612-617, 1984.

[21] M. Sorgato, D. Masato, L. Piccolo and G. Lucchetta. Plastic intensity reduction using thermally insulating coatings for injection molds. CIRP Journal of Manufacturing Science and Technology. 2020.