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Reuse of materials through the development of an automated prototype for cutting glass bottles

Cláudio Faria Lopes Junior[1], Gabriel Soares da Silva[1], Pedro Alcino Soares Lavinas[2], Regina Coeli da Silveira[2], Diego Dornelas Diogo[2]
[1]Department of Metallurgical Engineering, Fluminense Federal University, Brazil
[2]Department of Mechanical Engineering, Geraldo di Biase University Center, Brazil
Corresponding Author: Cláudio Faria Lopes Junior

Abstract: *The present work had the intention of developing an automated prototype for cutting glass bottles, which is able of reusing materials that were previously discarded in inappropriate places, causing a great impact on the environment, as well as to donate the same to a philanthropic entity non-profit private law, being the APAE of Barra do Pirai-RJ. The project was developed integrally in the Machining Laboratory of the University Center Geraldo Di Biase - UGB, using bibliographical, descriptive and exploratory researches, in order to establish the necessary concepts for the construction and execution of the project, besides experimental stages that were divided between the computational modeling until the construction of the prototype. The reuse of the material through the prototype generated qualitative results, being these, the transformation of glass bottles into pencil holder, candle holders, glasses, lamps, among other by-products.*

Keywords: *Automated prototype, Glass bottle, Material, Reuse, Sustainability.*

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I. Introduction

Due to the high index of incorrect disposal of materials in general, there is a great concern of the society with the environment and its repercussions for the next generations. Among these materials, glass is especially notable for having a much higher decomposition time when compared to other materials that are discarded [1]. With this, searching for strategies and alternatives for the sustainable disposal of this specific type of material, the present work had the objective of developing a prototype which is summarized in an automated machine to cut glass bottles, and its process makes available to society a device having as its raw material containers of disposable glass bottles. In this way it is possible to reduce the incorrect disposal of waste in the environment, giving another end to this raw material and guarantee a result that benefits society in particular. This can be in addition to a form of reuse of material, also a source of income, making the bottles become cups, jars, cups, lamps, candle holder, pencil holder, among other objects.

Therefore, the proposed study was developed through bibliographical and exploratory research, as well as being based on applied research through experimental stages in the Machining Laboratory of the Geraldo Di Biase University Center – Campus of Barra do Piraí/RJ. Initiatives such as these, aimed at the reuse of materials are necessary in today's world, not only by the scientific society, but also with companies, increasing the commitment to sustainability, thus contributing to the conservation of the environment.

II. Theoretical Perspective

2.1 Waste and society

Due to the increasing consumption of industrialized products, society is facing great adversity, each time a product is consumed another by-product is generated. These by-products are known as residues, and can be found in three physical states, being: solid, liquid and gaseous. Waste disposal has become a worldwide problem due to the fact that when not treated or disposed of properly, it can lead to water, soil and air pollution [2]. Figure 1 below shows within three years the significant increase in the apparent consumption of a specific category of waste, in the case of packaging. It can be observed that the most consumed containers are paper/paperboard, followed by glass and steel.

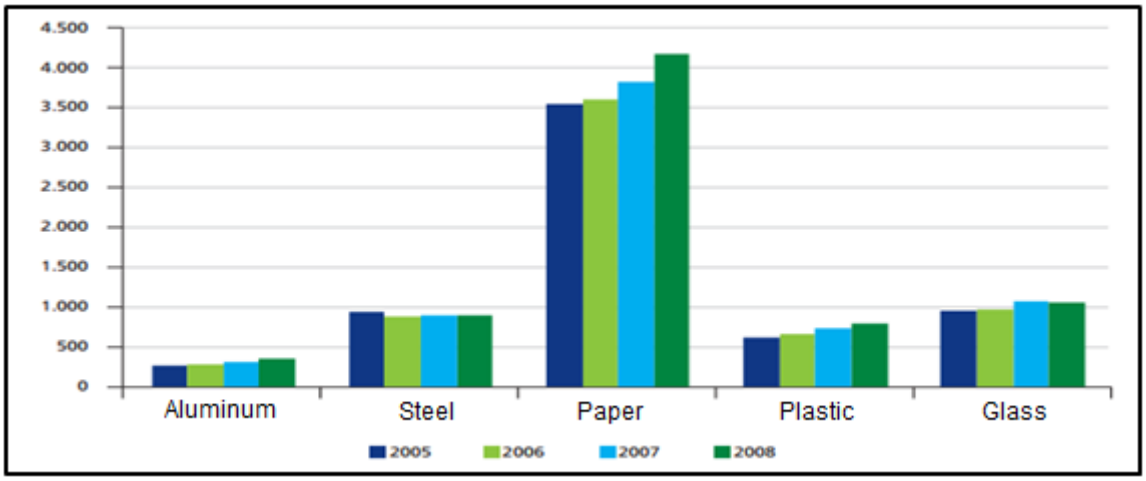

Figure 1: Apparent consumption of packaging [3].

2.1.1 The use of glass as packaging

Due to its properties and characteristics, glass has been widely used in packaging, such as food jars, containers for pharmaceuticals, bottles and glass bottles for liquid storage, among many other applications. It is important to emphasize some properties that justify this wide applicability of this material, being these the transparency and its neutrality, where the glass being a neutral material does not react chemically with the stored material, thus the product does not undergo alterations of flavor, color or quality of food [4]. In addition to these previous points, research indicates that the consumer prefers to use glass containers when compared to other types of materials, according to Figure 2 below, in which it demonstrates two surveys, one of them being carried out in North America and another in Europe, both carried out in 2014. Therefore, research such as this warms up the market for the manufacture of glass containers, since consumers support this material as a means of storing products.

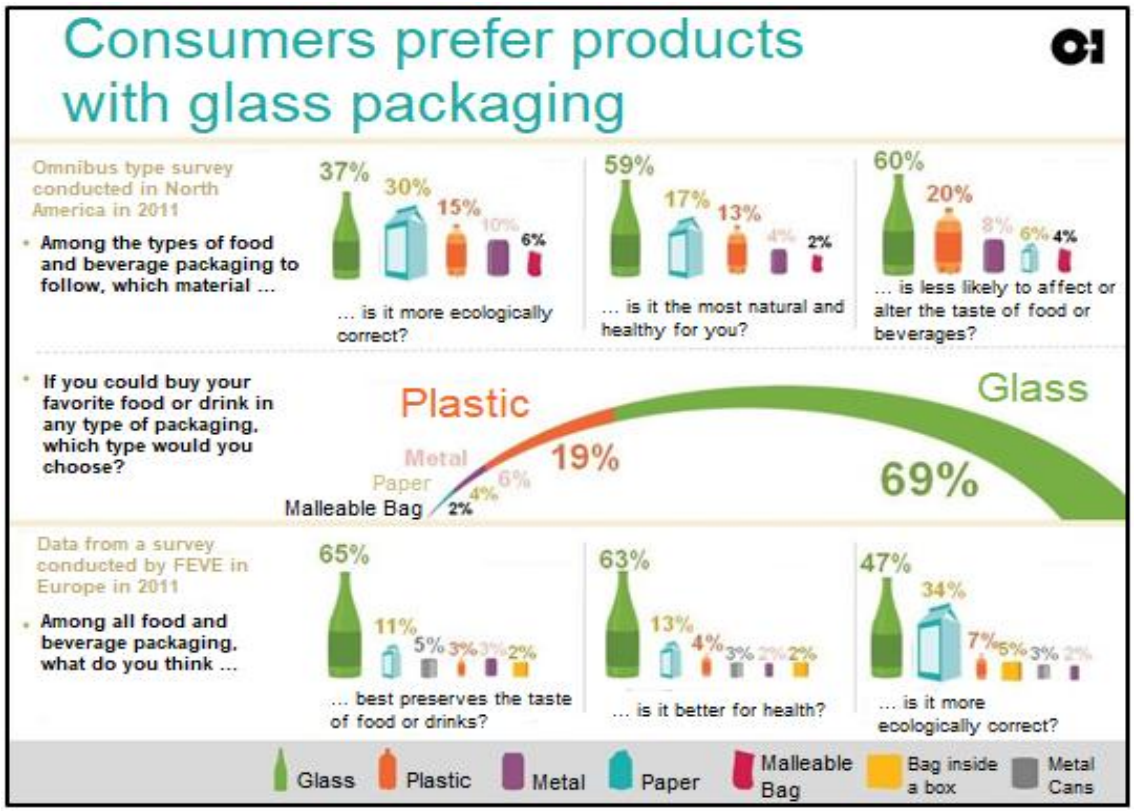

Figure 2: Preference of glass as packaging [4].

2.1.2 The impact of glass on the environment

As a result of the increasing use of glass for packaging, due to its composition, when not correctly discarded directly affect the environment, being exceptionally reluctant to climate change, it can take a long time to spontaneously decompose, which can vary from 4,000 years to 1,000,000 years. This shows that it has become a problem of great environmental and financial impact, since it is estimated that 7.5% of the total weight generated in the world of garbage is glass [5].

According to Figure 3-a, it was possible to observe that glass represents more than half of the material found in urban waste in Brazil in 2006, with a percentage of 57% among materials. In contrast, Figure 3-b demonstrated that glass is the second material less recycled in the state of Rio de Janeiro in 2007, having a low percentage compared to other types of materials that undergo this type of process [6].

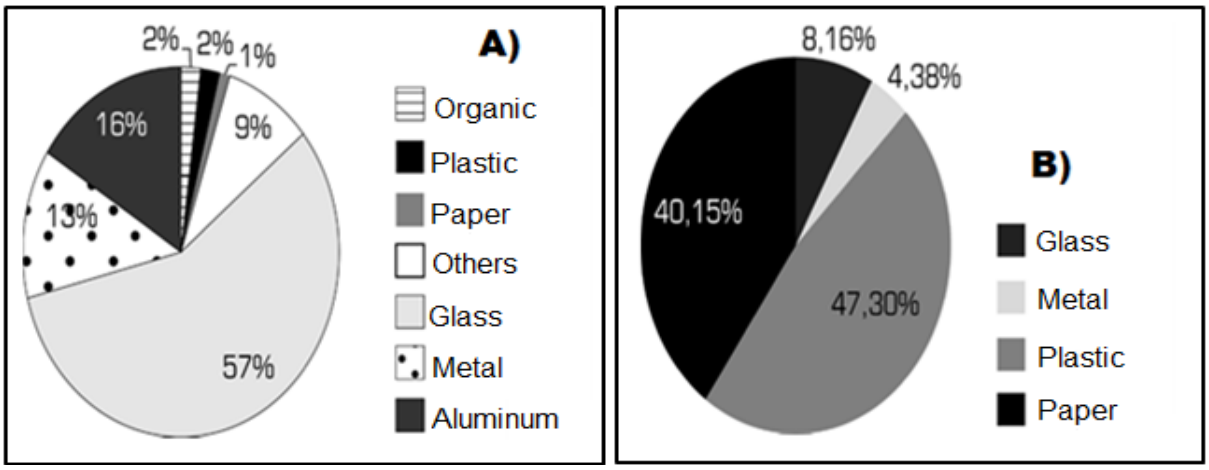

Figure 3: a) Composition of urban waste in Brazil in 2006. **b)** Percentage of materials recycled in Rio de Janeiro in 2007. [6].

2.2 Glass transformation

The transformation of glass is essential to be able to submit it to reuse processes, in order to use the same material for other purposes. In this way, it is extremely important to understand the transition process between its states, being solid to liquid, or vice versa. Thus, as shown in Figure 4, the moment of change of state is given by the transition temperature (Tg), which is actually not a fixed point, but a range, and within this range can assume several values according to material cooling rate and with the melt temperature expressed by (Tf), which is a fixed temperature according to each type of glass [7].

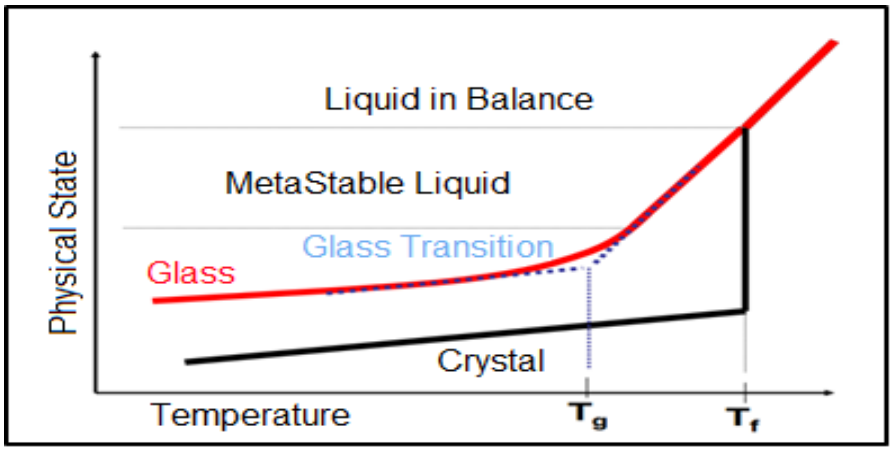

Figure 4: Glass transformation graphic [8].

Figure 4 shows that there are two prime temperatures to understand the transformation between the physical states of the glass, however, as such temperatures vary for each type of glass, it is important to classify the data according to the classification from which it will be used. In the case of bottles used in reuse processes, the classification of glass is known as Glass-Sodium-Calcium, due to its excellent characteristics that fully meet the requirements for a good container manufacturing. With this, this type of glass ended up becoming the system in which it has as characteristic the greater manufacture of the present world, arriving to be 85% of all

manufactured glass. Its temperatures are set forth, the melt (TF) being 1500°C and the transition temperature (TG) of approximately 550°C. However, the transition temperature may vary according to the cooling rate, due to this characteristic, it is not stipulated as a fixed point, but as a process temperature range [8].

2.3 Engineering for sustainability

In view of environmental problems, engineering is increasingly present in the area of sustainability, in addition to the area of waste management, in this way, society has been increasingly concerned with developing machines that help in the reuse and recycling of materials. One of the sectors that most use this type of machines are the brewing industries, where the process of aesthetization of the bottles occurs, seeking their reuse and thus increase the useful life of the same In this way, it is not only the society itself that has been worrying about the sustainability of engineering projects in favor of the environment, since nowadays companies are increasingly worrying about social sustainability, where they are committed to reducing the environmental impact, due to waste generated by its products or processes [9].

2.4 Processes developed for reuse of glass

Currently in Brazil the most used and known processes for the reuse of glasses are blow in torch with blowtorch, blow in cane and fusing, also known by vitrofusion, as shown in Figure 5. Such processes use hot techniques, that is, with heat as a source of transformation of the glass, whereby the material passes into a malleable state, where it can be molded and transformed into a new product. These demonstrated processes have as main characteristic the decrease of the deposition of the glass in inappropriate places in the environment, thus avoiding impacts that cause a series of problems for the society. Besides contributing to the generation of jobs, generating income for a material that would previously be unusable and discarded in the environment. Thus, through these types of processes, this waste issue can gain other ends, and these are more advantageous for the whole community [10].

Figure 5: Process of Fusing or Vitrofusion, Process of blowing in torch with blowtorch and Process of blowing in cane [10].

III. Methodology

3.1 Materials

The materials used for the construction of the prototype were divided according to the experimental stages, firstly the AutoCAD software was used for the computational modeling of the machine. Then the construction was started, where it was made the base of the project in which the metal was used as the main material of the structure and two endless screws for movement of the axes. Soon after the end of the assembly stage of the base, started the automation stage of the project which consisted of the installation of two motors of electric glass and one of microwave, so that the bottle when fixed to the base of the prototype can move through electrical commands installed in the design, from wires, connectors and a source to change the voltage of the motors. Therefore, after the automation stage, the final step was started where the marble stone and the electric resistance were fixed, besides the finishing steps, these grinding and painting of the structure and its components.

3.2 Methods

3.2.1 Scientific Methodology

For the execution of the prototype, bibliographical, descriptive and exploratory researches were carried out in order to establish the necessary concepts for the construction and execution of the prototype, being the theoretical analysis the first step in order to list the technical concepts on which the project is based. Therefore, the next step of the project becomes possible, being this one its assembly from experimental stages, in which it is based on applied research. In addition, this study aimed to generate qualitative results, as it increased the quality of the use of by - products generated in the prototype by society from the reuse of unusable and disposable raw materials, this being glass.

3.2.2 Computational Modeling

The first phase of the project consisted in the computational modeling of the prototype from the AutoCAD software, illustrated by Figure 6, where all the simulation was done, from its structure to the assembly of its components, being these mechanical and electrical, giving rise to automated machine to cut glass bottles. This stage helped singularly the development of the experimental part of the whole project, since it allowed the estimation of the materials to be used and the simulation of its dimensioning through the structure.

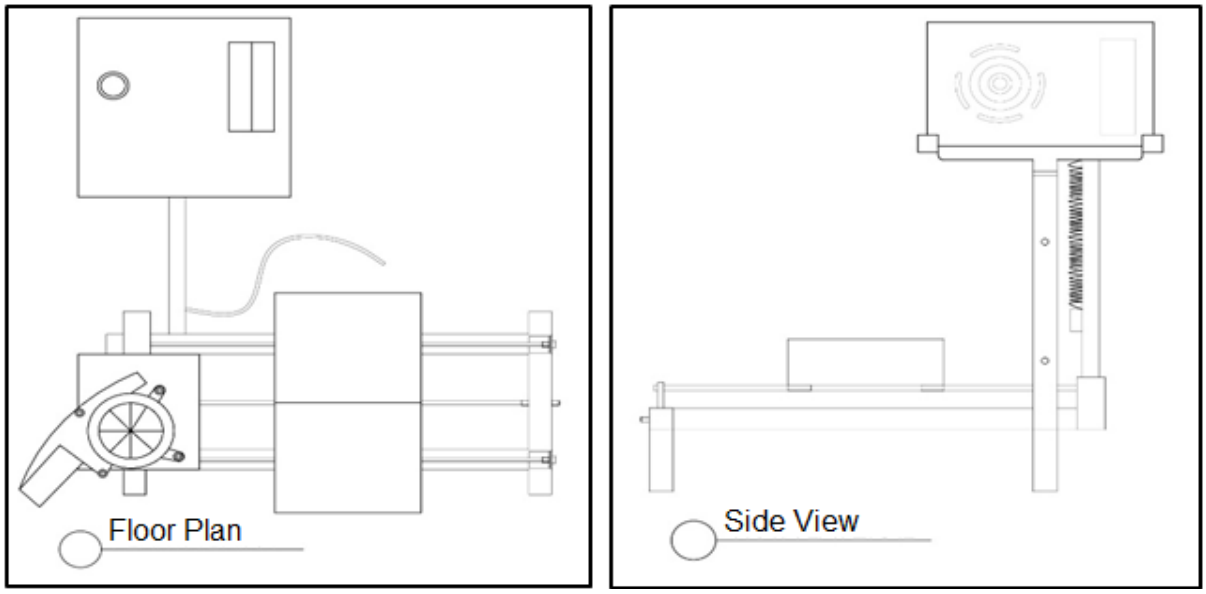

Figure 6: Computational Modeling of Prototype.

3.2.3 Prototype Construction Steps

The construction steps of the prototype consisted in the elaboration of the metal structure, with a V-shaped marble holder fixed to the base of the device, it was completely isolated so that the electric resistance heated the body of the container without having contact with it. The circuit connecting this resistor has been screwed close to the holder and close to the V-shaped base, having a perfect fit when the bottle rotates. Then, a microwave motor was used, this being applied in parallel to the resistance, thus, both the resistance and the motor, which originate the rotation of the bottle are simultaneously driven.

The second part of the project consisted of fixing stages of the electric glass motors, in which the first one has the purpose of moving in its vertical axis, regulating the height of the bottle through a system of racks and gears with two ends of courses, which serve to delimit its maximum and minimum limit, later it was fixed above the engine of rotation of the bottle, this being the one of microwaves, already installed previously in the project. The second engine had the purpose of the movement to determine the length of the cut of the bottle, making movements in the horizontal axis of its structure. At the moment of making the electrical connection of these motors, a source was used to change the voltage from 12v to 110v, allowing the connection of the prototype in home environments.

In addition, the marble piece was fixed in the structure, where it served as the base for the installation of the electric resistance, which cuts the bottle. Finally, the electrical connection of a button system was carried out in order to control all the automated part of the project, as shown in Figure 7.

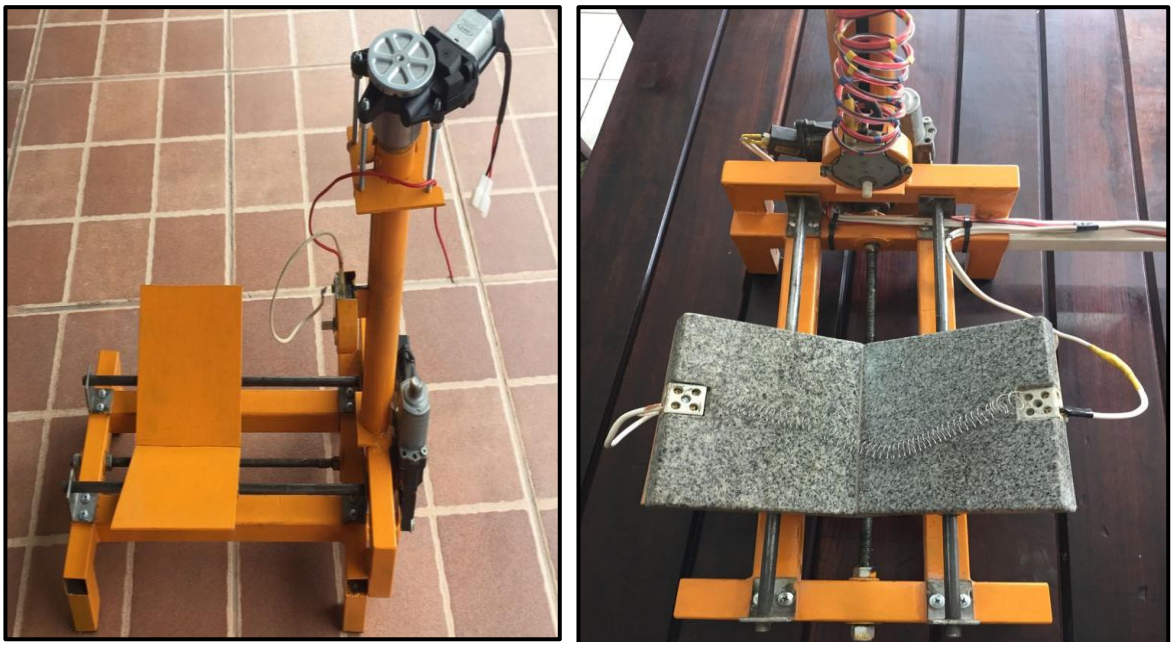

Figure 7: Stages of construction of the bottle cutter.

IV. Results and Discussions

4.1 The prototype

The following work resulted in the automated prototype of a glass bottle recycling machine, shown in Figure 8, transforming these containers into pencil holders, candle holder, cups, lamps, among other by-products. Being that, after tests carried out in the project, it was possible to prove that the productivity of the prototype is of 6 bottles per hour, taking into account that each bottle becomes two new products, so every hour of production the prototype generates 12 new products, which can be used in the way you wish, being possible to use and / or commercialize them.

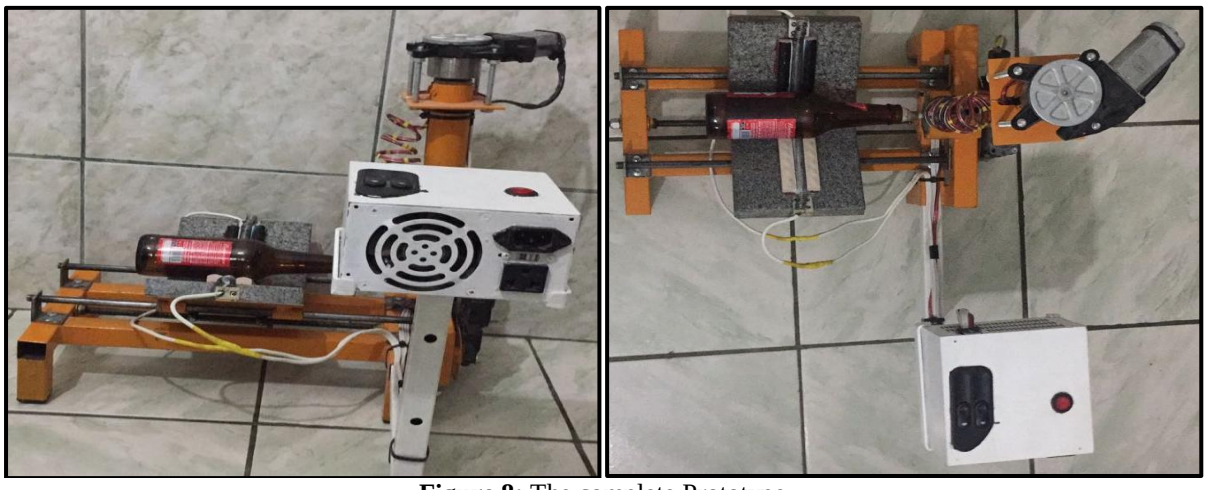

Figure 8: The complete Prototype.

4.1.1 Flowchart of by-product manufacturing process

As can be seen from the flowchart elaborated in Figure 9, the project is part of a process of reusing a specific material, which consists of the collection part of the glass bottles, which is carried out by manually selecting the users of the prototype, through the hygienization stages, which consists of cleaning by means of a solution of soap and water, capable of eliminating dirt and contamination, in addition, fixing the bottle in the prototype, cutting the bottle through it, and if necessary, give the finishing by means of burr breaking of the final product and / or sanding thereof, finally the use or commercialization of the by-products generated. As evidenced, in addition to reusing the glass containers that were previously dumped into the environment, this process generates income from the sale of its final byproduct.

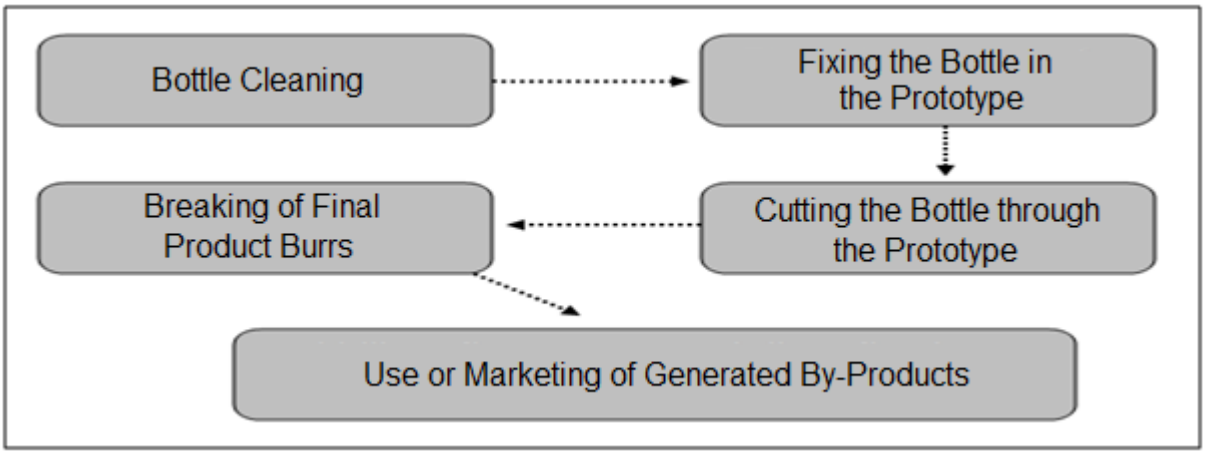

Figure 9: Flowchart of by-products manufacturing process.

4.1.2 By-products generated in the process

The by-products generated by the automated machine to cut glass bottles in the process of reuse of these containers are: pencil holder, candle holders, glasses, lamps, among other by-products shown in Figure 10. Due to the automation of the design, the production of these by-products occurs in series, besides guaranteeing a good quality of all the objects resulting from this process, also it avoids any human failure that could happen if its process were manual.

Figure 10: By-products example.

4.2 Discussions

Based on the discussion of the work, the real impact that the prototype reflects on society and the environment, considering facts such as the reduction of soil contamination due to improper glass discards, and the use of engineering for the transformation of these the same materials in by-products with added values, contributing to the transmission of a sustainable culture, where it can influence in some way the daily life of society. Since this project can be of use not only industrial, but also the use of the same in domestic environments, since it allows the minimization of the various problems caused to the planet, as previously exposed by this study.

In addition, the discussions generated by the project in question are also due to the dissemination of research for a social purpose, ensuring that society is in fact the main beneficiary of the research results. It is also the donation of the same to a private nonprofit philanthropic entity, this being the Association of Parents and Friends of the Exceptional - APAE of Barra do Pirai-RJ, whose main objective is to promote integral attention to the person with intellectual disability and multiple.

4.2.1 Delivery of the prototype to the APAE

As one of the initial objectives of the work, the delivery of the prototype to the APAE as shown in Figure 11 was chosen because there is a need and a current shortage of funds that the institution is going through, because of the lack of private support and cuts in public funding. Therefore, this initiative was well accepted by all those involved in the institution, from students, teachers, families and their managers.

Figure 11: Delivery of the prototype to the APAE.

4.2.2 Commercialization of by-products by APAE

The commercialization of the byproducts generated by the process of reuse of glass by the prototype developed and later donated to APAE, had as purpose the generation of funds for the institution, since it has the need to generate resources for its own survival. In addition to having a fundamental role for the continuity of the work developed by the Association, as evidenced in Figure 12.

Figure 12: Commercialization of by-products by APAE.

V. Conclusions

The final considerations of the present work are of great value to society, due to the fact of meeting the initial objectives of the whole project, these being to reduce the environmental impact that the incorrect disposal of glass bottles causes in the environment, besides helping an institution that has the real need to generate funds for its survival, through the commercialization of the by-products generated from the process carried out by the developed prototype. In this way, initiatives like this are of paramount importance to contribute to a sustainable environment and the development of actions that guarantee a benefit for people and institutions that have real needs and lack of aid.

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