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The New Complete Solution on Recycling Plastic Bottles

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***Abstract*— Current levels of plastic usage and disposal is one of the biggest environmental challenges that needs to be resolved. Collecting and recycling plastic is one of the most important actions currently used to meet this challenge, but it represents one of the most demanding areas in the plastics industry today. A major percentage of recycled plastic produced each year is used to manufacture disposable packaging items or other short-lived items that are discarded within a year or so. This means that the current use of plastics is not sustainable. In addition, due to the durability of the polymers involved, large amounts of discarded end-of-life plastics are accumulating as debris in landfills and in natural habitats worldwide. Energy efficient plastic recycling processes involve a complex system of machines and new manufacturing practices. This paper discusses a new promising environment friendly solution for reducing pollution by recycling plastic bottles. The project has both economic and social value. It is especially important to eliminate contamination from burning and melting plastic material and increase public awareness of environmental protection for the benefit of humanity. A progressive sustainable economic model of entrepreneurial partnership is presented for the developing economies.**

Keywords—Recycling solution, Plastic Bottles,Recycling Management

I. INTRODUCTION

Plastics in general and containers (bottles) are a rapidly growing segment of Municipal Solid Waste (MSW). While plastics are found in all major MSW categories, the containers and packaging category had the most plastic tonnage at over 14 million tons in 2017 [1]. This category includes Polyethylene Terephthalate (PET) bottles. Data in Tab.1 [1] depicts the main channels of management of plastic solid waste: recycling, incineration, landfill.

Plastic bottles find common use in a wide range of applications in our daily lives [2]. As a result of this use, plastic bottle production has increased remarkably over the years. According to recent research, the global production of plastic containers is estimated to reach 67.9 Million Metric Tons (MMT) by 2020; a compound average growth rate of 5.2 percent. The market was worth $273.15 billion in 2014 and will reach $388.35 billion in 2020 at a growth rate of 6 percent [3].

Table 1. 1960 – 2017 Data on Plastics in MSW by Weight (in thousands of U.S. tons)

Management Pathway	1960	1970	1980	1990	2000	2005	2010	2015	2016	2017
Generation	390	2,900	6,830	17,130	25,550	29,380	31,400	34,480	34,870	35,370
Recycled	-	-	20	370	1,480	1,780	2,500	3,120	3,240	2,960
Composted	-	-	-	-	-	-	-	-	-	-
Combustion with Energy Recovery	-	-	140	2,980	4,120	4,330	4,530	5,330	5,340	5,590
Landfilled	390	2,900	6,670	13,780	19,950	23,270	24,370	26,030	26,290	26,820

Sources: American Chemistry Council and the National Association for PET Container Resources

There is a high demand of plastic bottles, especially in the water and soft drink industry in America [3]. It has brought with it its severe environmental problems due to the careless disposal of these bottles [2, 4, 5]. In the early 2020s, our output of plastic waste rose more in a single decade than it had in the previous 40 years [6]. Statistical data reveals that people add up to 8-9 million tons of plastic waste to our environment each year, which includes up to 40% Polyethylene Terephthalate (PET), the clear plastic used for water and soda bottle containers. PET is low priced and produced in enormous quantities. Half of all marine plastic pollution is known to enter from a small geographic region involving only five countries, i.e., China, Indonesia, The Philippines, Thailand, and Vietnam [7]. The amount of the plastic waste discarded into Eastern Sea in Vietnam, about 0.28-0.73 million tons/year, ranks 4th in the world [8]. This impacts ships safety routing and contaminates fisheries. Traditionally, plastic waste is processed by burning or sending it to a land fill. The constant buildup of plastic waste in the landfills has become a major source of concern for many sectors of a sustainable society. The disadvantage of the combustion of plastics is the air pollution caused by the noxious fumes released into the atmosphere [9]. The adverse health effects of Carbon Monoxide gas (CO) and Carbon Dioxide (CO2) generated during the combustion process are well known, and create many harmful side effects [9, 10, 11].

The impact of burning one ton of hard waste creates about 62 cubic meters of Methane, which is equivalent to one ton of CO2 [12]. Around 6.3 million tons of plastics waste are thought to have been generated between 1950 and 2015, of which only 9% were recycled and 12% incinerated, leaving nearly 80% to accumulate in landfills or the natural environment [11].

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Massive pollution contaminates rivers and clogs drainage systems, usually ending up in the oceans due to people's negligence. Normally, plastic items can take up to 1,000 years to decompose in landfills. Plastic bags are used in our everyday life and take anywhere from 10 to 1,000 years to decompose, and PET bottles need at least 450 years to decompose [13]. CO2 gas pollutes the environment, and plastic waste affects landmasses and oceans. Another option for sustainable plastic waste management is the conversion into artifacts such as beads, bags, door mats, and hats. Recently, there has been research regarding a new method called pyrolysis, which recycles the plastic and recovers oil [15, 16]; however, this method faces the problem of variable quality and composition in the feed. The significant costs involved in the elimination of plastic contaminants should be addressed under the commercial success. From this analysis, the sustainable solution for recycling plastic bottles was introduced. This project concerns three main components:

- Design and setup the system for recycling plastic bottles in a new way, to eliminate disadvantages of the landfill, incineration, pyrolysis, including the traditional recycling.
- A Progressive sustainable economic model of Entrepreneurship/Partnership is presented for the developing economies.
- Through the project, integrate the environmental education for student with social sense

II. MATERIALS AND METHOD

The process of recovering plastic waste and reprocessing it into useful products would be implemented in the following ways:

Setup and Organize the Ecosystem for Collecting Plastic to be used for Water and Soda Bottles. A successful plastic recycling operation requires a dependable source of plastic waste and an efficient collection and separation system. To encourage participation in the process, the consumers are employed and involved in the process. This also strengthens and enhances a sense of community ownership and involvement.

Each household is provided with a green bin for collecting plastic waste and paid cash amount for their effort. A team of student volunteers was involved in this campaign. They are major students from University, who have the engineering knowledge and social relation skills to convince the local community about the progressive advantages of this process. They also collected the comments from the community to apply them to the project's design.

II. Design, Manufacturing, and Production

A specific set of machines have been designed to convert Polyethylene Terephthalate (PET) plastic waste into plastic ribbons/wires. The ribbons/wires in turn are subsequently woven into scores of useful artifacts.

The mechanical design specification is as follows: Cutting plastic (PET) bottles into ribbons with different widths, connectin g and coiling.

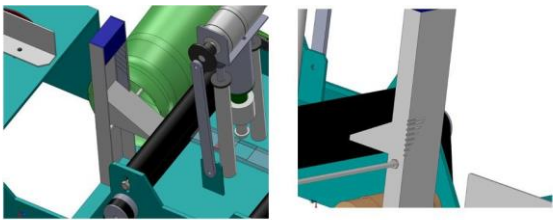

Figure 1 Cutting bottles into ribbon with different widths

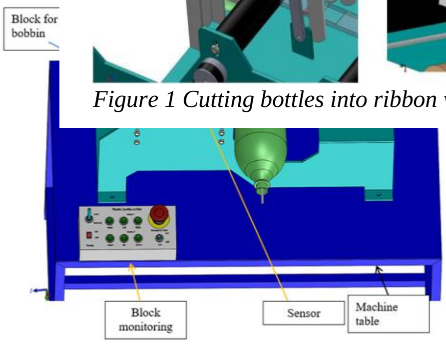

Figure 1 Ribbon Cutting Machine Block Diagram

Overall Dimensions: 700 mm x 300 mm x 300 mm
Size of machine table: 820 mm x 500 mm x 500 mm

The Ribbon Cutting Machine presented in Figure 1 is the block diagram representation of the prototype Machine, which is designed and developed for the purpose of shredding the recycled plastic bottles into respective widths of plastic ribbons.

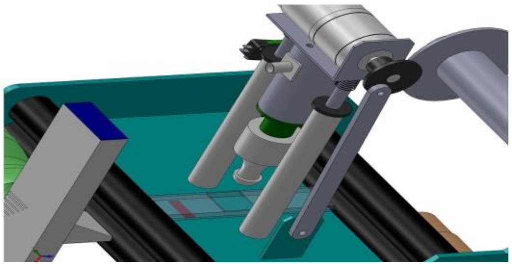

Figure 2 Device for Connecting Plastic Ribbon

In Figure 2, the ribbon is continuously feeding and is adjusted for some overlap. At this juncture, the ultrasound heater is utilized for connecting individual pieces into a continuous plastic ribbon. The quality and appearance of the ribbon depends on welding parameters settings. The capacity of this machine is also a subject which is beyond the scope of this paper.

As different widths of ribbons are needed for various end products, the machine, as seen in Figure 3, must have the ability to cut plastics into various widths. The machine accomplishes this requirement by adjusting the position of the knife (sliding the blade-knife), which in turn regulates the width of cutting ribbons.

As seen in Figure 4, the bobbin is freely rotating and the ribbon is being wound. The diameter and width of the bobbin is calculated so the process takes about 20-30 bottles per lot. An upgrade of this device can apply to two scenarios:

- Automatic stopping the machine when the bobbin is full.

- Continuous recharging of the bobbin.

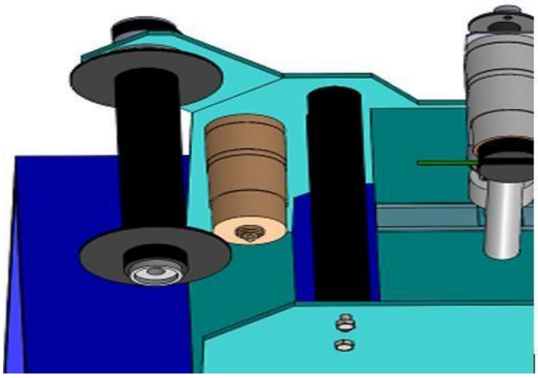

Figure 2 Device for Bobbin Ribbon

III. MICROCONTROLLER I/O INTERFACE SCHEMA FOR SENSING AND CONTROL

The overall schema for machine controlling system for the relevant hardware functionality is shown inFigure 5. Multiple inputs sought from the control panels and respective sensors are utilized as input to the processor. The respective output signals for controlling the two motors (cutting and bobbin/connecting) are being generated as per the algorithmic design for the machine.

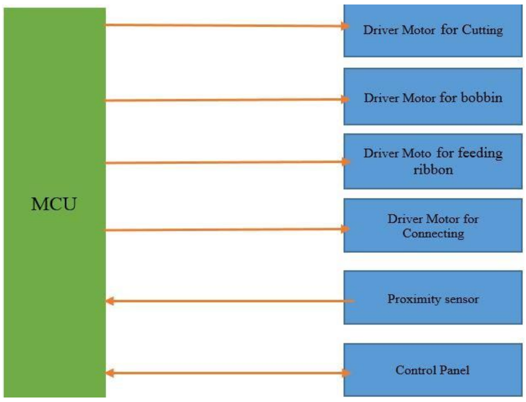

Figure 3 Schema for Machine Controlling System

This scheme is applied for the machine on which, cutting, connecting by ultrasound welding, and winding the ribbon. The motor for connecting is a process that presses the ultrasound welder on overlap of ribbon to connect them. The motor for cutting indicates that it drives the blade knife to cut at the bottom and body of bottle into a ribbon. The motor for feeding means the ribbon after cutting needs to be supplied to the area of welding. The motor for bobbin means it rotates the bobbin for wounding. The warning sensor indicates that the system needs to feed the next ribbon so that the overlap can be correct and the welder can properly connect them.

As the structure of the bottles is circular, the resulting plastic ribbon is spiral and not flat. As such the ribbon does not meet the requirements for product processing stages. This require further flattening of the ribbon without changing its characteristics by applying continuous modulating and regulating the temperature under the algorithmic control. A top view of the extricate machine is

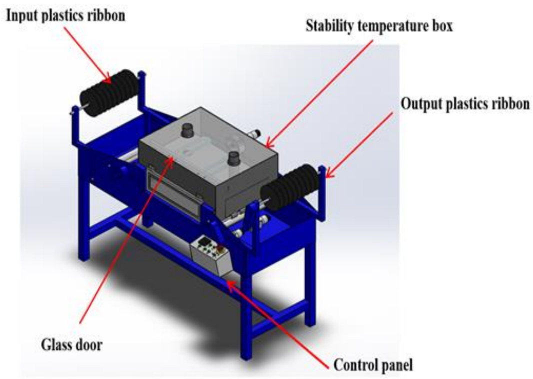

Figure 6 Extricate Plastic Machine

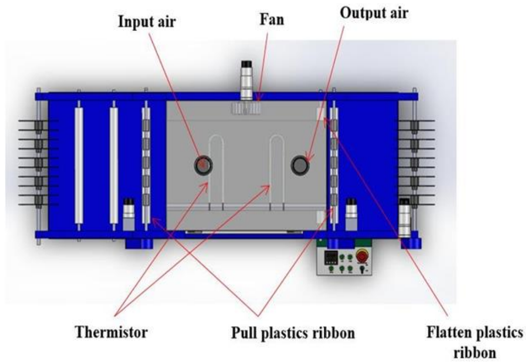

Figure 7 Top View of Extricate Machine

shown in Figure 6 and 7.

IV. PLASTIC KNITTING MACHINE

The Knitting Machine, as seen in Figure 8 and 9, is for knitting plastic Ribbon/wire. Depending on the specification of the end product, the machine regulates the knitting process.

The following steps discuss the concept in a simplified manner.

- Two wires are being fed from the two sides continuously.

- One strip of plastic runs horizontally through the machine with the help of tension in the strip generated

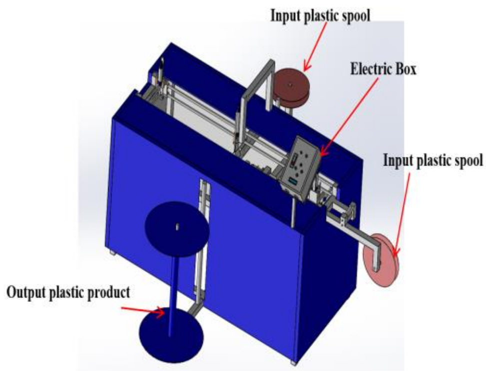

Figure 8 Plastic Knitting Machine

by the output spool (yellow strip below).

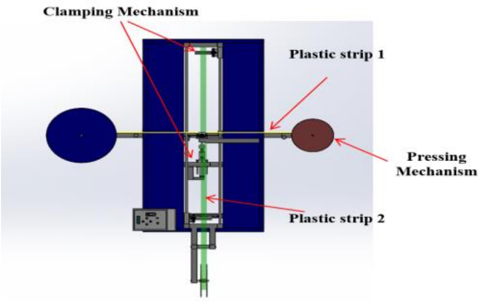

Figure 9 Top View of Knitting Machine

- One strip of plastic is fed with the help of clamping device; it will stop when the end of the journey reaches 140 centimeters.
- Using pressing mechanism to fold plastic strip in half. Afterwards, an ultrasonic welder is used to achieve the desired fusion of plastic strips.
- After fusion, the scissors cut plastic strip 1, then plastic strip 2 continues to advance.

The machines are manufactured, tested, and ready for deployment for Green Environment Initiative for Recycling Plastic Bottles Entrepreneurship Partnership.

V. Typical Products Made from Recycling Plastic Ribbon/Wire

The end product and artifacts, shown above in Figure 10, have been tested as samples in the prototype machines and are ready for deployment for Recycling Plastic Bottles Entrepreneurship Partnership Program.

Figure 10 Typical Products Made from Recycling Plastic Ribbon/Wire

VI. CONCLUSIONS

The Relationship between Entrepreneurship and Economic Development for Developing Economies summarizes and updates the empirical evidence, then presents the main lines of reasoning behind the relationship between economic development and entrepreneurship [17]. Given the scenario that even though a small percentage (in low teens) of success stories of entrepreneurship, this is a tremendous toll for the very high failure rates on the financial wellbeing of startup individuals. This is a big gamble with regard to scourging the hard earned wealth and wellbeing of the families present and future. This should give the policymakers of government agencies a pause for the developing economies, as whether this is the best path forward.

The University, government agencies, and the private entrepreneur would form a three-prong partnership which would have a very high probability of success. The two parties, namely governmental agencies, could take care of financial burden in a partnership with the individual or joint entrepreneur in a (80 to 20) relationship. The individual or joint entrepreneur would be responsible for day to day management of the entity. The University, the third party would provide the technical and scientific backbone to the entrepreneurship as described here.

The authors feel the above described scenario would have high likelihood of success for economies, like that of Vietnam, in developing countries. This will be a win-win situation for the individuals and society and would result in a clean and green environment. Also, the new approach is presented – the human sense and design skill, entrepreneurial experience to settle the actual social problem in developing countries is integrated.

The project has both economic and social values. On the economical side, this will help to reduce all expenditure for waste processing related to destroying the plastic waste. The second important contribution of the project is the significant impact on employment creation, specifically in rural areas. Lastly, the recycled plastic is used to make new plastic products that could be sold at an affordable price point for low-income families. On the social side, this will improve environmental conditions, reduce landfill waste, prevent spreading of diseases due to recycling plastic, eliminate contamination from burning and melting plastic material, and increase public awareness of environmental protection for benefit of humanity.

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BIOGRAPHIES

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