Ceiling Tiles from Recycled Plastic Product and Process Design

Tarmy Abbot, Samanta Mendez Barona, Charlese Pratt, Makayla Rozsa-Grover
Dalhousie University – Department of Chemical Engineering

Background Information

Plastic waste represents a growing global issue for the environment. Research for innovative ways to recycle plastic waste has intensified in recent years. There is a great opportunity to develop sustainable materials created from recycled plastics within the building industry.

Introduction

This project focuses on the design of ceiling tiles made from recycled high-density polyethylene (HDPE) plastic. The design of the ceiling tiles includes determining the manufacturing process as well as selecting the appropriate materials to achieve the required properties.

Objective:

- Create marketable design and product at a relatively reasonable price while maintaining profitability.
- The end-product must be created from recycled plastic and must also be recyclable at the end of its lifecycle.
- The ceiling tiles must meet all applicable building code requirements.

Figure 1: Shredded HDPE Plastic [1]

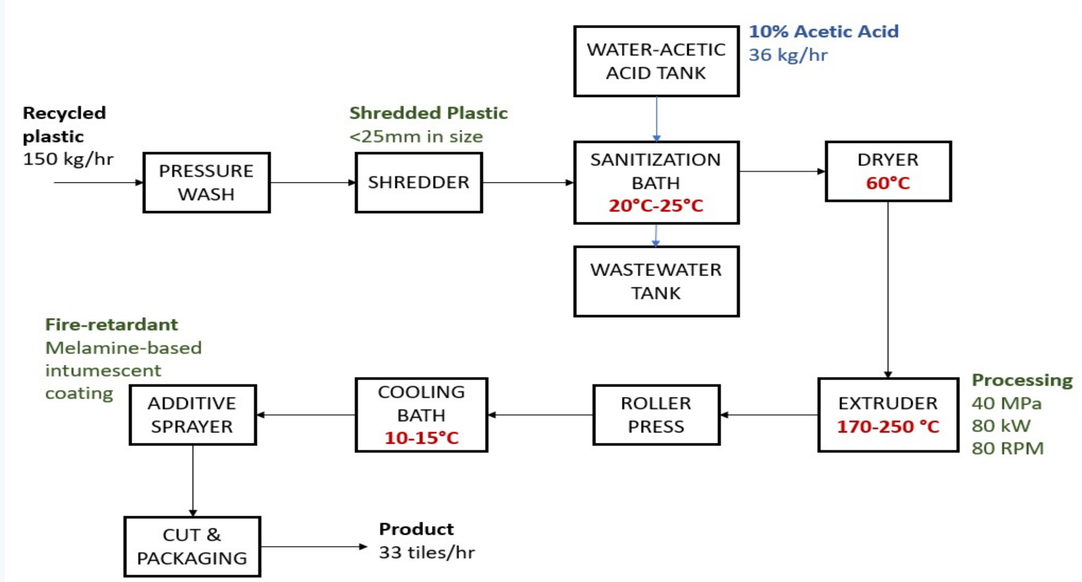
Design Process

Table 1: The main design considerations and method of approach for this project.

Design Considerations	Design Approach
Material selection: Type of plastic and required additives	Multicriteria analysis
Operating conditions for manufacturing process	Heat and mass transfer analysis
Tile geometry	SolidWorks simulation
Safety	What-if analysis
Profitability	Economic analysis

Details of Design

- Color-sorted bales of HDPE are pressure washed, shredded, chemically cleaned, air dried, melted via extrusion, pressed and cooled to the desired shape. The fire-retardant additive is then applied, followed by cut, packaging and finally, distribution.



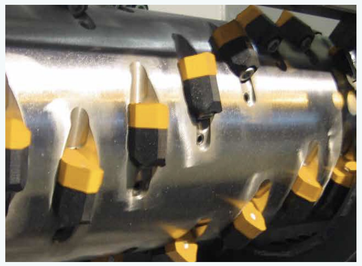


Figure 2: Plastic shredder [2]

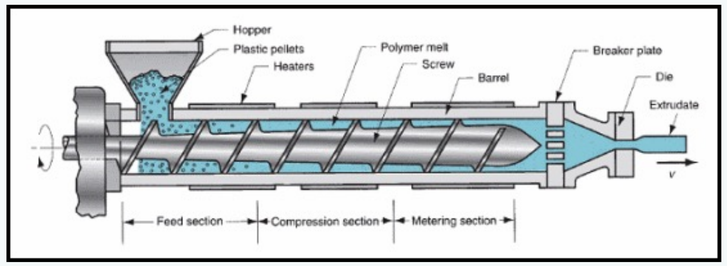
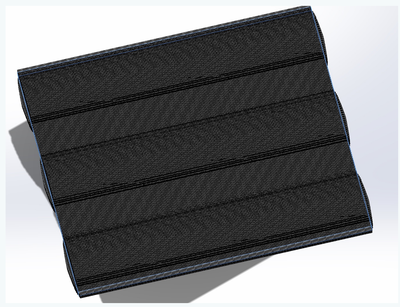


Figure 3: Plastic extruder [3]

- HDPE Tile dimensions are 24 mm x 24 mm with an adjusted base thickness of 12.7 mm (reduced from 19 mm).
- Weight of tile: 4.58 kg = 10.09 lbs.
- SolidWorks buckling simulation used to determine deformation of tiles under loads. The tile can hold 10 N with a deflection of 3.317mm.
- Drop Ceiling Installation.
- Fire retardant is a melamine based intumescent coating with a thickness of 1.14mm.



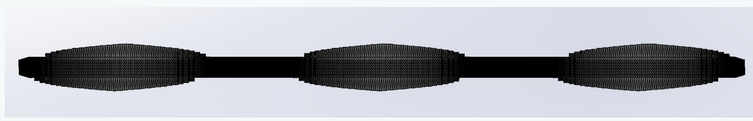


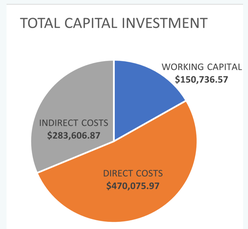
Figure 4. Side View of tile, straight knurl texture with cylindrical pattern.

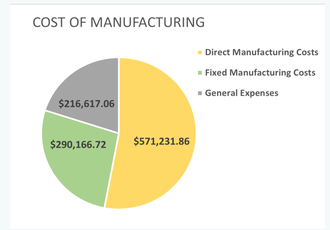
- Flat surface thickness: 12.7mm.
- Cylindrical pattern height and spacing: 8.42 mm from base in the positive and negative y direction, 92 mm apart along the x axis.

Economic Analysis

Table 1: The main contributors to the yearly cost for manufacturing a recyclable ceiling tile.

Economic Analysis	
Fixed Capital Investment	$753,682.84
Working Capital	$150,736.57
Total Capital Investment	$904,419.40
Depreciation	$67,831.46
Cost of Manufacturing	$1,055,918.21
Cost of Manufacturing per tile	$12.32
Revenue	$1,214,514
Profit	$133,366.49
Return on Investment	14.52%





- The projected project life is 10 years.
- Market value of 24mmx 24mm plastic tiling range from $4 to $80/tile.
- The price of the tile was scaled up from $2.74/kg, based on manufacturing costs, to $3.15/kg or $14.18/tile.

Conclusion and Recommendations

The design objectives were successfully accomplished.

- Tile design meets all building standard codes
- Design reduces the amount of HDPE entering the waste stream.
- The cost of manufacturing allows the tile to be profitable and have a 14.5% ROI

For future work, it is recommended that

- a pilot plant be developed for further process optimization
- lab testing be conducted for enhancement of the tile's mechanical properties

References

[1] L. (2020, November 19). The big sly trick to get rid of plastic waste: pretend it's fuel. Plastic Soup Foundation.from: https://www.plasticsoupfoundation.org/en/2020/11/the-big-sly-trick-to-get-rid-of-plastic-waste-pretend-its-fuel/

[2] UNTHA LRK Class Shredders (July 2020) LRK Class 1-Shaft Shredder for high performancee requirements in material recycling. Retrieved from: https://www.untha-america.com/shredders/industrial-shredders/lrk700/1000/1400_p1688

[3] PTFE Machinery. (2021, March 30). Polymer Screw Extrusion Introduction. Retrieved from PTFE Machinery: https://ptfemachineryblog.wordpress.com/2017/02/22/polymer-screw-extrusion-introduction/