Densification of Post-Consumer Expanded Polystyrene

Association Canadienne de l'Industrie des Plastiques

ACIP CPIA

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1.0 Introduction

Expanded Polystyrene, or EPS, packaging materials are bulky, lightweight and present unique challenges for small-scale collection and recycling facilities. However, these materials have a growing North American market, provided that products can be adequately reduced in volume to render transportation cost effective.

Typically, an EPS cushion package consists of 2% polystyrene and 98% air. Removal of the air by mechanical or thermal densification results in a weight-to-volume ratio 30 to 50 times greater than the raw EPS package.

Densification will tend to lock in contaminates, lowering or negating the value of the densified materials. It is therefore important that metals, paper and non-polystyrene polymer be excluded from the densifying process through adequate screening controls or sorting of incoming materials.

Commercial densifiers typically have rated capacities in the range of 15 to 450 kilograms per hour. Moisture on EPS feeds will reduce production rates and can result in overloading of mechanical densifiers.

Electrical power consumption ranges from 1.5 kW to 70 kW or more.

Densifiers operate with substantial mechanical forces and/or at temperatures high enough to cause serious burns. Equipment manufacturers have incorporated safety devices into designs; however operators should be properly trained in the use of any densifying device. Thermal densifiers should be adequately vented in accordance with local regulations.

2.0 Available Equipment

A number of commercial EPS densifiers are now available in size ranges to suit most common applications. Some EPS recyclers have developed proprietary equipment and offer buy-back programs for the densified EPS materials. The equipment described in the following is not a comprehensive listing of all the equipment intended for the purposes of densifying EPS. The equipment summary is to provide an overview of the various types, capacities and costs of typical commercial densifiers.

2.1. Mechanical Densifiers

Mechanical densifiers work by exerting sufficient pressure on the EPS products to break the walls of the cellular structure and squeeze out the entrapped air. The final bulk density of the densified material is dependant on the amount of mechanical force applied, but may be as high as 400 kg/m^3.

The pressure exerted should be adequate to produce a semi-friable block capable of retaining its shape during subsequent handling and transport.

Manufacturer: Runi A/S

Type – Screw Compactor

Available Models:

Model Number	Nominal Capacity	Final Density	Power Requirements	Approximate Cost
SK 120	18 kg/hr	~300 kg/m^3	1.5 kW	US $12,000
SK 240	70 kg/hr	~270 kg/m^3	7.0 kW	US $45,000
SK 370	200 kg/hr	~300 kg/m^3	16 kW	US $62,000

Manufacturer: KBM. Styrocompactor

Type – Screw Compactor

Available Models:

Model Number	Nominal Capacity	Final Density	Power Requirements	Approximate Cost
Micro	15 - 20 kg/hr	125 -200 kg/m^3	1.5 kW	US $ 11,500
Micro 1 Phase	15 - 20 kg/hr	125 -200 kg/m^3	1.5 kW	US $ 12,500
Mini	35 - 45 kg/hr	175 -250 kg/m^3	4.0 kW	US $ 18,000
Maxi	70 – 90 kg/hr	175 -250 kg/m^3	7.5 kW	US $ 26,600

Manufacturer: Matrix Manufacturing Inc.

Type – Hydraulic Compactor

Available Models:

Model Number	Nominal Capacity	Final Density	Power Requirements	Approximate Cost
Polymax 1000	~20 kg/hr	250-315 kg/m^3	15kW	US $12,000
Polymax 2500	70 kg/hr	250-315 kg/m^3	12 kW	US $ 27,000
Polymax 5500	110 kg/hr	250-315 kg/m^3	15 kW	US $ 50,000
Polymax 6500	225 kg/hr	250-315 kg/m^3	22 kW	US $ 75,000

Manufacturer: Sebright Products, Inc.

Type – Hydraulic Compactor

Available Models:

Model Number	Nominal Capacity	Final Density	Power Requirements	Approximate Cost
Bright D 30	135 kg/hr	250-315 kg/m^3	12 kW	US $ 65,000
Bright D 120	500 - 600 kg/hr	250-315 kg/m^3	22 kW	US $ 100,000

2.2 Thermal Densifiers

Thermal densifiers use a heat source to dissolve the cellular structure of the EPS and liberate the entrapped air. High-density solid blocks or 'blobs' are created with this technology. Density of the recycled material may reach over 600 kg/m^3. Some machines incorporate a mechanical screw to force material through a heated densifying zone.

Certain designs may require a holding area for air cooling of the densified materials. The cooling time will depend on a number of factors; however the cooling time for densified blocks greater than a few centimeters in thickness can be expected to be measured in hours. Stacking of blocks will increase the cooling time.

Heating of polystyrene material can cause the release of vapours into the workplace. The presence of contaminates such as paper or other polymers may contribute to the vapour production. Optional venting devices are available with the thermal densifiers referenced in this document. Comments on the effectiveness of these venting measures to meet local workplace safety regulations, the nature of the vapours generated or local permitting requirements for exhaust to the atmosphere are beyond the scope of this report.

Manufacturer: Taylor Products Limited (StyroMelt)

Type: Thermal convection

Available Model

Model Number	Nominal Capacity	Final Density	Power Requirements	Approximate Cost
TP 1000	15 kg/hr	> 600 kg/m^3	13 kW	US $ 32,000

Distributor: Demand Foam Cutting Systems

Type: Thermal/mechanical

Available Models

Model Number	Nominal Capacity	Final Density	Power Requirements	Approximate Cost
FD 10	32 kg/hr	~500 kg/m^3	7.5 kW	US $ 12,000
FD 25	90 - 135 kg/hr	~500 kg/m^3	18 kW	US $ 32,500
FD 120	180 - 270 kg/hr	~500 kg/m^3	18 kW	US $ 55,500

Manufacturer: RecycleTech Corp.

Type: Thermal/mechanical

Available Models

Model Number	Nominal Capacity	Final Density	Power Requirements	Approximate Cost
XT 200	90 kg/hr	~500 kg/m^3	16 kW	Consult Supplier
XT 400	180 kg/hr	~500 kg/m^3	48 kW	Consult Supplier
XT 500	225 kg/hr	~500 kg/m^3	48 kW	Consult Supplier
XT 700	320 kg/hr	~500 kg/m^3	48 kW	Consult Supplier

3.0 Applications

3.1. Municipal Recycling Programs

Materials collected through municipal curbside collection programs are typically processed through a Material Recovery Facility (MRF). Experience shows that polystyrene collected and processed through these facilities contains cross polymer and non-polymer contamination in levels of 5% -20%. These materials must undergo a secondary sorting process prior to recycling into new products. Densifying contaminated materials imbeds the undesirable materials to a degree that makes further separation difficult or impossible.

Modern MRFs are typically equipped with powerful horizontal balers capable of producing a polystyrene bale suitable for transport to polystyrene processing markets without the need for further capital investment. Baled polystyrene can be expected to reach densities in the range of 30% to 60% of those achieved by utilizing a dedicated polystyrene densifier.

In the event that a MRF operator is able to segregate clean (virtually free of paper, metals, glass, dirt and non-PS polymers) polystyrene foam, the use of a PS densifier could yield the following benefits:

- elimination of baling PS, freeing up baling equipment for higher volume materials;
- enhance revenue, clean, densified PS foam will have a significantly higher market value than a contaminated baled stream;
- lower transportation costs to market; and
- broader market competition for densified material.

3.2 Depot Collection Programs

Polystyrene materials collected through supervised depots are likely to be substantially free from contamination and therefore suitable for densification. The resulting product will be saleable to several markets throughout North America. Certain densifier suppliers may enter into contractual arrangements to purchase the densified product.

When considering a densifier for a depot collection system the following factors should be carefully reviewed:

1. Equipment capacity – expanded polystyrene materials are extremely light-weight. A small capacity machine, as rated in kg/hr., will handle a large volume of polystyrene foam.
2. Storage capacity – a machine operating at 20 kg/hr will require approximately 900 hours of operation to accumulate a truckload of densified product, or roughly 6 months, based on continuous operation 8 hours per day 5 days per week.

3. Return on Investment – Depot scale densifiers may be expected to generate marketable product, which at current prices may yield gross revenues of $6.00 to $12.00 per hour.

3.3 Packaging Return Centres

Packaging return centres (PRC) have been established in several North American jurisdictions. These are attended "store front" locations that accept a variety of recyclable materials directly from individual consumers. It can be expected that limited storage space is available, precluding the option of accumulating truckload quantities of polystyrene for shipment to markets. For illustration, two possible solutions for handling EPS packaging in a return centre operation are presented. Both scenarios assume that the PRC is part of a network of centres within a catchment area. A fifteen location network has been assumed in both cases, with each location handling 40 kgs/day of EPS cushion packaging material.

PRC Scenario 1

Small-capacity densifiers occupy a narrow footprint and may be situated along a suitable wall in the PRC. The incoming EPS materials would be placed into the machine hopper by the PRC centre attendant and the machine would be cycled as necessary when the hopper is full. Small quantities of densified materials would be shipped on a regular basis with other recyclables to a central processing facility for amalgamation with materials from other PRC's in the network. It is assumed that no additional staffing is required for the operation of the machine. A simplified cost/benefit example of this system is presented in Table 1.

TABLE 1
PRC SCENARIO 1

Scenario 1	Each PRC Location	PRC Network
Equipment - RUNI SK100	1	15
Densifying Rate kgs/hr	18	270
Material Receipts kgs/day	40	600
Equipment Operating Hours/Day	2.2	33.3
Equipment Energy Requirements (kW)	1.5	22.5
Energy Cost @ $0.10/kWh	$0.33	$5.00
Additional Labour @15.00/hr	N/A	N/A
Daily Revenue @ $300/tonne	$12.00	$180.00
Net Daily Revenue	$11.67	$175.00
Annual Net Revenue (365 days)	$4,258.33	$63,875.00
Estimated Capital Cost (Installed)	$14,000	$210,000.00
Simple Payback (years)	**3.3**	**3.3**

PRC Scenario 2

Under scenario 2, loose EPS materials would be collected and bagged at each individual PRC. The bagged materials would be shipped with other recyclables to a central material handling facility. The central facility would be equipped with a medium-capacity densifier (in this example 70 kg/hr) and an operator would be dedicated to processing the loose material through the machine. The additional labour cost offsets much of the revenue; however the lower capital cost of this approach still yields a higher rate of return than the operation of individual units located at each PRC. Table 2 shows an example of the economics for a centralized densification process.

TABLE 2
PRC SCENARIO 2

Scenario 2	Each PRC Location	PRC Network
Equipment - Matrix Polymax 2500	0	1
Densifying Rate kgs/hr	0	70
Material Receipts kgs/day	40	600
Equipment Operating Hours/Day	N/A	8.6
Equipment Energy Requirements (kW)	N/A	12.0
Energy Cost @ $0.10/kWh	N/A	$10.29
Additional Labour @15.00/hr	N/A	$128.57
Daily Revenue @ $300/tonne	N/A	$180.00
Net Daily Revenue	N/A	$41.14
Annual Net Revenue (365 days)	N/A	$15,017.14
Estimated Capital Cost (Installed)	N/A	$32,000.00
Simple Payback (years)	**N/A**	**2.1**

4.0 Industrial/Commercial Waste Cost Avoidance

Retailers, manufacturers, distribution companies and other institutions may receive expanded polystyrene packing in large volumes. Past practice has been to landfill these products; however there are significant costs associated with this waste-handling option. In these cases, densifiers may present an excellent opportunity for cost elimination with the added bonus of potential income from the sale of densified materials.

Densifiers provide an opportunity to reduce waste transportation cost or, if the product can be kept free from contamination, revenue can be generated from the sale of the densified product. An example analysis for a company that generates approximately 18 kg/hr (the nominal capacity of a small densifier) of expanded PS, is presented in Table 3. This assumes a 40 hour per week operation. The base case assumes the disposal method is an open-top, forty cubic yard (30 cubic metres) standard waste bin.

Data is given for the same operation utilizing a compactor to reduce waste volume by a 3:1 ratio.

Two scenarios are presented for densified polystyrene; the first assumes that the PS material is sent for disposal and the fourth assumes that the material is clean enough for the competitive PS recycling market, thus producing a revenue stream.

In all cases material handling labour, if any additional is required, is an added expense.

TABLE 3
DENSIFIER COST/BENEFIT ANALYSIS
INDUSTRIAL/COMMERCIAL OPERATION

Open 40 Yard Container		**Savings vs. Base Case**
3 lifts/week		
Quantity (tonnes/week)	0.73	
Disposal Cost @125/tonne	$91.85	
Transportation @ $125/lift	$375.00	
Total Weekly Cost	$466.85	
Total Annual Cost	**$24,276.41**	**$0.00**
40 Yard Compactor Bin		
1 lift/week		
Quantity (tonnes/week)	0.73	
Disposal Cost @125/tonne	$91.85	
Transportation @ $125/lift	$125.00	
Total Weekly Cost	$216.85	
Total Annual Cost	**$11,276.41**	**$13,000.00**
Option 1 - Densify/Dispose		
1 lift/10 weeks		
Quantity (tonnes/week)	0.73	
Disposal Cost @125/tonne	$91.85	
Transportation @ $125/lift	$12.50	
Total Weekly Cost	$104.35	
Total Annual Cost	**$5,426.41**	**$18,850.00**
Option 2 - Densify/Sell		
Quantity (tonnes/week)	0.73	
Revenue ($/week@$300/tonne)	$220.45	
Total Annual Cost	**($11,463.38)**	**$35,739.79**

Assumptions	
Disposal Cost	$125/tonne
Waste Transportation	$125/trip
PS Density	
Open Bin	35 kg/cubic metre
Compactor	105 kg/cubic metre
Densified	300 kg/cubic metre
Revenue for Densified PS	$300/tonne

5.0 Appendix A

Densifier Contacts

Demand Foam Cutting Systems
1055 Nine North Drive
Alpharetta, GA 30004
Tel: 1-800-325-7540; 770-772-7448
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