Recycling of plastics from stockpiles performed by means of low-pressure injection

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Abstract

A viability analysis of manufacturing goods out of plastics, from stockpiles and municipal residues, has been carried out. The analysis pertains goods in the form of inserts manufactured in light molds of big-sizes, by means of low-pressure injection. The cost analysis of the investment and manufacturing suggests that those goods are not price-competitive, as compared to other ones used in similar situations. Exploitation analysis proves that the goods, used outdoors are easily damaged on the surface by UV exposure, temperature differences of 24-hour cycle, as well as by water and plants. Re-recycling, and especially, the grinding of the product poses another challenge in the future. An analysis of the environmental impact of energy acquisition during the manufacturing of those goods was also carried out. The analysis also pertains the method of identifying the type of raw-material, in the process of segregation that stems from the necessity of a complex content training of stuff running waste segregation posts.

Keywords: innovative materials and founding techniques, environmental preservation, flaws of casts

1. Introduction

The usage of plastics as a recyclable raw material from municipal stockpiles served as a basis for the creation of a processing line for manufacturing of big-sized inserts in light molds, by means of low-pressure injection. The environmental impacts, as well as the amount of pollution emitted in the process of re-utilization of plastics, the viability of this process, the competitive value on the raw materials market, the durability of products, their resistance in the given usage in the outdoor environment have not been analyzed well enough at that point. This requires an analysis to be carried out stemming from the project of a processing line used to manufacture products from plastics for specific purposes, such as: stockade, paving blocks, flowerpots, rainwater grillwork. A differen analysis pertains the viability of both including subsidies for "environmentally friendly" action and without them, as well as the final analysis of potential re-recycling of the plastics used in the aforementioned products.

2. Methodology

A project of the processing line has been created. The line will be used to manufacture elements made of a plastics (20 Mg annually) and plastic wrap (30Mg annually) mix. Based on the aforementioned project, calculations were made that include the cost of investment in the processing line (with required analyses, permissions, and agreements regarding the adaptation of rooms for storing plastics), the cost of manufacturing (including the calculation of amortization write-offs, individual costs, cost of energy and water), the analysis of competitive advantages on the...
3. Description of the processing line

Adaptation will concern production wastes and plastic containers that belong to a group of polyolefines with the exception of PCV, ABS and polystyrene foam /Styrofoam/. The adaptation will be carried out by means of the processing line. The general schematics of the line are shown in figure 1. The schematics marking:


Plastics, after generic segregation will be delivered to:
- the mill /2/ plastics and wraps, tapes, bags and thin-walled containers to the thickener.
- After grinding and thickening in the thickener and the mill, the raw materials go into the dispensers of tanks /3 i 4/.
- In set quantities /volume/ the raw materials are transported on worm chutes. /5 i 6/ to
- the Drier /8/, equipped with an agitator to unify and rid the agglomerate of water.
- After the operation is finished the drier is emptied completely and the raw materials are inserted into the transition tank via chute /11/.
- From the tank, plastics are dispensed into the press-form /13/.
- Worm press-form operates (the process of filling) the forms. /14/
- After being filled, the forms are cooled-down in a tub filled with water. /15/.
- Then, the forms (to obtain ready-products) are manually disassembled on the table. /16/.
- the ready-products are moved onto the frames.

The adaptation of wastes is generally based on grinding and mixing in right proportions, heating up to the temperature of flexibility, inserting into the form, cooling-down and the removing of a solidified, ready-product. Generic segregation conducted by trained employees will consist of selection of polyolefine hard plastics of bigger sizes, PE and PP and all types of plastic wraps. Hard plastics – household chemistry containers, oil containers etc. mostly have letter markings placed on products, and plastic wrap products /gardening foil, construction foil, grocery wrap, bubble wrap etc./ don’t have them. It’s a known fact that most plastic wraps are useful for processing. Unmarked products should be dismissed. Only after a specialized identification takes place, they can be introduced into the process. If, in the identification process, a mistake happens, a small quantity of the misidentified plastic inserted into the bigger amount will not substantially deteriorate the properties of the ready product. /boxes, bowls, metal-free toys./

4. Required properties and the characteristics of machines and processing line equipment

The mill is a device for grinding waste, post-production and post-utility dirty plastics. The desired average size of the plastic particles after grinding should amount to 6 – 8 mm. The intake of the hopper funnel at should be at least 250x250mm, the minimum grinding efficiency: 50kg/hour. The device should have a sound-proof cover. The thickener – a device for grinding and thickening dirty plastic wrap wastes made of polyethylene of low and high density /PE-PD i PE-HD/ in the form of sheets, wrapping and gardening foil, tapes, bags, thin containers etc. The device needs to be efficient at the level of 30kg/hour for agglomerate density of 0,4kg/dm³. Additionally, the device requires a water clarifier to be used after washing process and a ventilation hood that makes it possible to connect a stay that removes steam.

The agitattor-dryer is a device used for mixing grinded plastic of a size between 6mm and 8mm and the plastic wrap, thickened in the thickener, according to the weight relationship. The device needs a mixture-warming system of a power of 3kW installed for draining water. The mixing and drying chamber capacity is 500 dm³. The cover is tight, over the device there is a ventilation hood to carry vapors mixed with fine particles of the mixture. Worm press-form adapter for manufacturing elements made of dirty plastic that carries hard contaminations /sand etc./ that influence the durability of the system: cylinder-worm. The worm geometry
should be selected in a way that the lowered injection pressure can secure the process of pouring of plastics into the thin-walled forms. The worm diameter should be 45 mm, rotating speed 120 – 200 rpm. Hopper needs to be equipped with a tape feeder that prevents the stalling of sharp-edged grinded plastics, mixed with plastic wrap /special properties/. The output of flexible plastic from the press-form cylinder takes places vertically in the top-down direction. The shape and the diameter of the output hole for flexible plastic needs to be agreed on. Maximum efficiency up to 80kg/hour. Worm chute, 4m long equipped with additional delivery hole with a Bolt, located mid-way on the chute. The hole needs to be equipped with a connection stub pipe. Maximum chute efficiency – 100kg/hour for grinded plastics and thickened plastic wrap. The chute should be equipped with an intake, on one end, that ensures the feeding of plastics from a box-type container. The supporting construction needs a construction project.

5. Cost Analysis

Table 1.
Investment Cost

<table>
<thead>
<tr>
<th>Type</th>
<th>Unit</th>
<th>Gross Cost</th>
<th>Net Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill pln</td>
<td>79300</td>
<td>65000</td>
<td></td>
</tr>
<tr>
<td>Thickener pln</td>
<td>95160</td>
<td>78000</td>
<td></td>
</tr>
<tr>
<td>Worm chutes pln</td>
<td>2928</td>
<td>2400</td>
<td></td>
</tr>
<tr>
<td>Agitator pln</td>
<td>6100</td>
<td>5000</td>
<td></td>
</tr>
<tr>
<td>Dispenser pln</td>
<td>7320</td>
<td>6000</td>
<td></td>
</tr>
<tr>
<td>Worm press-form</td>
<td>119560</td>
<td>98000</td>
<td></td>
</tr>
<tr>
<td>Tub+tables pln</td>
<td>12200</td>
<td>10000</td>
<td></td>
</tr>
<tr>
<td>Forms pln</td>
<td>12200</td>
<td>100000</td>
<td></td>
</tr>
<tr>
<td><strong>Total pln</strong></td>
<td></td>
<td><strong>444568</strong></td>
<td><strong>364400</strong></td>
</tr>
</tbody>
</table>

Table 2.
Manufacturing costs

| Energy pln | 49941.7 |
| Individual costs pln | 144000 |
| Amortization pln | 47092  |
| **Total pln** | **241034** |

| Total pln | 685602 |

The manufacturing of elements with and without the subsidies from Narodowy Fundusz Ochrony Środowiska (National Environmental Preservation Fund), are compared with the cost of a typical concrete paving block. The results are presented in figure 2. In figure 3, the cost comparison of products that weigh below 1.5 kg is presented in fig. 3.

The analysis shows that the processing Line for products that weigh below 1.5 kg can be competitive, with an Assumption of SPBT return-period on investment is 12 years, subsidies are present.

Such analysis can lead to false conclusions that subsidies for products should be reinstated, that would allow the recycling of plastics to be competitive against, e.g. concrete products. The final product can be subject to surface destruction caused by UV exposure and temperatures. The destruction takes place in a couple of years. That’s why a new analysis pertaining the re-recycling, but this time the one of products of high, consistent mass. The results of cost comparison in presented in fig.4.

The comparisons proves that the product in not price-competitive.
6. Environmental impact

The production line for elements made of a plastics and plastic wraps mix, despite securing the required hermeticity of devices, will be producing solid and gas contaminations and causing their emissions into the atmosphere. The amount of pollution will be small, but the process specifics require the use of operative local ventilation. Because of that, research was carried out and locations, where ventilation hoods should be mounted, over the anticipated places of emissions were identified. The amount of hoods depends on the periodic operation of a device placed on the processing line, that should, as a result, ensure the security of working conditions. Because the real emissions quota is unknown for certain devices, it is advisable to mount ventilation hoods only after the line is operational. Thus, the amount of hoods and their configurations can be subject to change. As a consequence, an environmental impact report can be formally prepared. Figure 5 compares the pollution amounts that were delivered during recycling of materials, while figure 6 presents CO₂ emissions.

![Fig. 5. SO₂, NO₂, CO emissions including dusty, sooty and benzpyrene emissions](image)

![Fig. 6. CO₂ emissions.](image)

The CO₂ emissions are twice as high.

7. Conclusions

The use of manufactured products, under the influence of UV and temperature will limit the exploitation time to a couple of years. UV radiation causes surface destruction and discoloring. The analysis of the purposefulness of introducing this technology in the future should include the cost of Re-recycling. The grinding of big-sized elements poses a challenge which is connected with a high energy demand that’s characteristic of the grinding process that leads, at the same time, to a substantial pollution of the environment.

References