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Plastic grow kit design project

Proyecto de diseño de un kit de cultivo de plástico

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Abstract

Objective: The development of a product aimed at the recreation sector such as toys for children can represent many obstacles due to the public to which it is addressed and the problems that come to reflect with the efficiency of the plastic material and how that can affect the product itself.

Method: Our starting point in this project was to make research about products that were already made, we had to became familiar with the materials commonly used for the invention of toys, know its properties until we find the ideal material for our product which in the end it turned out to be the HDPE of SABIC. Then based of previous knowledge we wrote the functional analysis of the product to characterize the functions offered by our product to satisfy the needs of our users. Next, we capture the ideas in a pulse sketch to be able to later make an electronic sketch with the help of a SolidWorks to make the idea tangible and do the necessary changes to the problems that progressively presented themselves to us. In fact, the invention of the toy evolved as we went along, this was precisely the strongest barrier of the whole assignment.

Furthermore, we decide based on our judgment and research that the best method to make our culture kit was through injection, because it benefits us in the aspects of time and cost of the process. Consequently, we had the task of carrying out mechanical resistance tests in the Mold Flow software to ensure that our design was practical.

Contribution: Finally, we had to obtain the approximate cost of machinery in the production invested on our piece, which gave us a cost of about 4.938 €. And that helped us to obtain countable results from simulations, such as the cycle time.

Plastic material, Injection, Costs

Resumen

Objetivo: Desarrollar un producto dirigido al sector de la recreación puede representar muchos obstáculos debido al público al que va dirigido y los problemas que se reflejan con las propiedades de la materia plástica definida que por consecuente impacta al producto mismo.

Metodología: Una investigación sobre productos en existentes con usos similares fue realizada con el propósito de familiarizarnos con los materiales que comúnmente se utilizan para la invención de los juguetes, conocer sus características hasta encontrar el material idóneo para nuestro proyecto, el cual resultó ser el HDPE de SABIC. Luego el análisis funcional del producto fue minuciosamente redactado para caracterizar las funciones que ofrece nuestro producto y de esta manera satisfacer las necesidades de nuestros usuarios. A continuación, se hizo la creación inicial del diseño a mano alzada y más adelante con la idea más clara, en el software SolidWorks.

Además, decidimos en base a nuestro juicio e investigación que el mejor método para hacer nuestro kit de cultivo es través de la inyección, porque nos beneficia en los aspectos de tiempo y costo del proceso. En consecuencia, diversas pruebas de resistencia mecánica fueron realizadas en el software Mold Flow.

Contribución: Finalmente, tuvimos que obtener el coste aproximado de maquinaria en la producción invertida en nuestra pieza, lo que nos dio un coste de unos 4.938 €. Y eso nos ayudó a obtener resultados contables de simulaciones, como el tiempo de ciclo

Materia plástica, Inyección, Costos

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Introduction

A leading company in the toy market, seeks to diversify by offering a brand-new product. This is a small plant growing kit for kids.

The kit includes a shelf with two trays, pots for cultivation, sachets of ready-to-use seeds, potting soil, instructions for use, a game board which presents the cultures of the seeds according to the seasons, and vegetable files.

The company calls on you for your plastics processing skills to help it in its search for solutions. She asks you to study the realization of the shelf only. It expects concrete implementation proposals from you.

Methodology

Functional analysis of the product

Identification of need: A toy company is looking to diversify by offering an innovative product. This is a cultivation kit for children to make them aware of the fauna and flora.

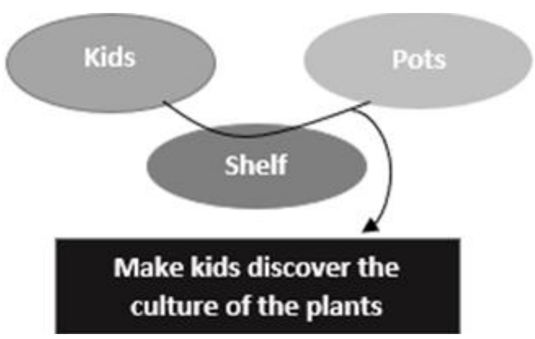

Figure 1 The horned beast diagram

Elements of the external environment:

CF1 (FP): Pots.

CF2: Support the pots.

Below are some elements of the file provided by the company.

Catalog selling price of the complete kit: between 12 and 18 per unit (public price). The shelf with the pots should not represent more than 60% of the total price.

Production forecast of 5000 units over one year.

Maximum shelf dimensions: length; 450, depth: 160, height: 330.

Two removable trays that can accommodate 8 pots each.

CF3: Resistant to shocks, moisture.

CF4: Meet the standards.

CF5: Handle with 2 hands.

CF6: Watering plants.

CF7: Move the shelf.

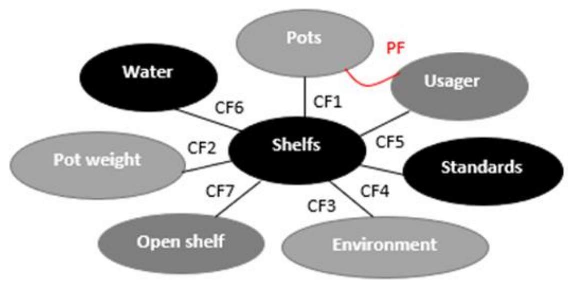

Figure 2 Octopus diagram

Characterization of service functions

Une fonction de service est une fonction attendue d'un objet technique pours répondre aux besoins of a given user (e.g., a child in our case).

Classes of flexibilities:

F0: Zero flexibility, imperative level

F1: Low flexibility, low negotiable level

F2: Medium flexibility, negotiable level

F3: Strong flexibility, highly negotiable level

Service functions	Requirement	Level	Flexibility
FS1 : Pots	Support the weight of the elements	Average of 600g per pot	F0
FS2: Support pots	Get an ideal and convenient weight to hold the pots	Average weight of 4.5 kg per tray	F1
FS3: Resistant to shocks, moisture	Resistant to moisture and temperature changes	1-4 years	F2
FS4: Comply with standards	Compliance with standards	ISO standards	F0
FS5: Handle with both hands	Light	About 4 kg per shelf (children over 6 years old)	F1
	Right measurements	A child's hand	F0
FS6: Watering plants	Support the weight added by the water	60g added 2-3 fois/semaine	F2
FS7: Move the shelf	Movement of the shelf and its total weight	Average of 9kg + / - 500g for the whole shelf	F0

Table 1 The service functions and their levels

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Implementation

Diagram FAST

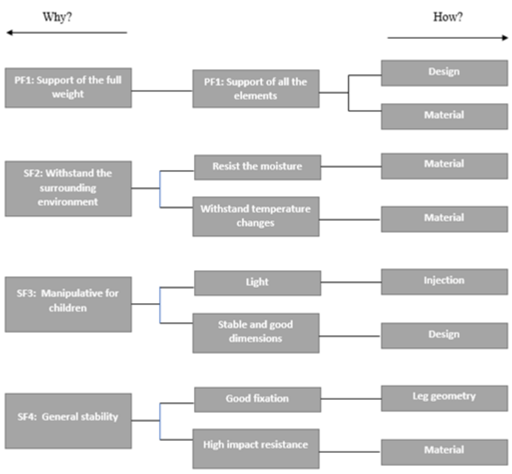

Figure 2 Fast diagram

Product Specifications

The purpose of the specifications is to put in writing the needs so that it is understandable to the different actors by defining all aspects of the project.

Grow kit	
Description :	"Kit for children" / Introducing plants to children
Deadline :	Week 27
Objective:	Create a grow kit for children that will teach them how to grow, the importance of the seasons in growing
Tasks: (Perimeter Elements)	Aimed at children over 6 years old Can be used indoors Easy to handle
Choice of materials:	• PPH, good strength/weight ratio, more rigid than the copolymer. • PP, very resistant to fatigue and bending. • PEHD good UV and shock resistance. (defined material)
Constraints :	• The project must be completed by week 27. • The budget for the project must not exceed 16€.

Table 2 Grow kit specifications

Sketch/design

Explanation:

Firstly, the idea was to make a design similar to a children's toy with rounded shapes and corners. Or this, we relied on toys shelf- like with two legs and floors that quickly mount / disassemble. For the part of the feet, we considered that it was appropriate that they should be square shaped for better stability on the ground.

Choice of the implementation process

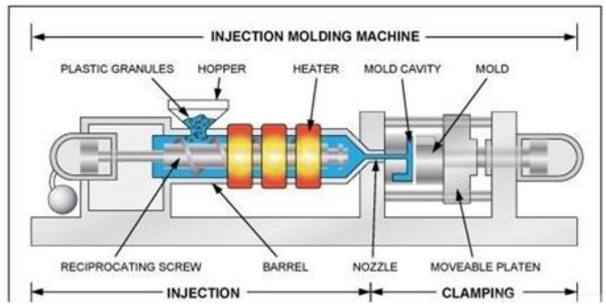

Figure 3 Injection machine scheme

Advantages	Disadvantages
Possibility of manufacturing in one operation	Complex form
Short cycle time	Lack of creativity for the public
Design Freedom/complexity	High tooling costs
Low process budget	Need of draft angles
Most suitable	Large mold

Table 3 Advantages and disadvantages of injection molding

For the rest of the project, we kept the idea of designing one product with the ability of being assembled.

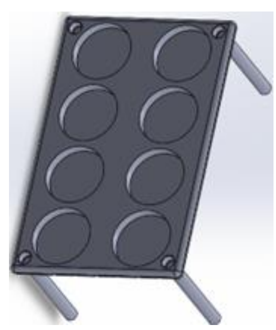

Figure 4

Chosen material

After an arduous investigation we decided that the material that was the most suitable for our application was HDPE for its usefulness being easy to process, tough grade with a good resistance to environmental stress cracking and low notch sensitivity. It has a grade of 28g/10min, which corresponds to an injection grade and the price is 1400€ per tonne.

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Final part and simulations

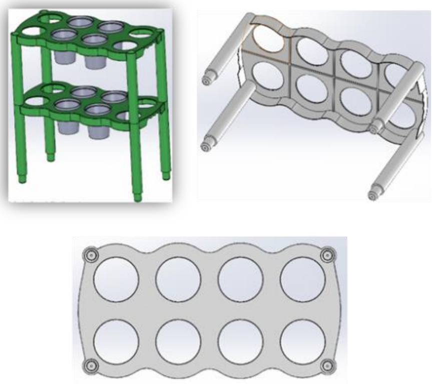

Figure 5

Technical drawing

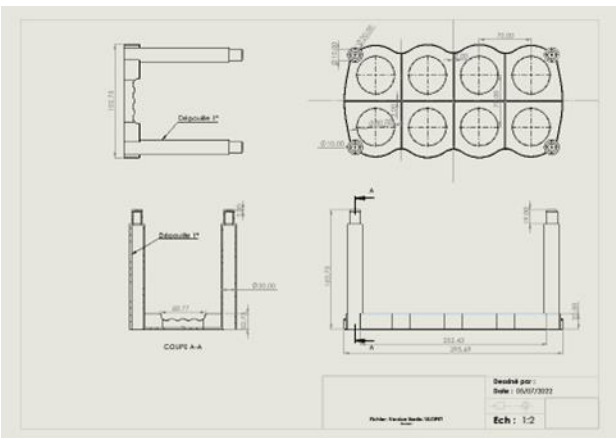

Figure 6 Technical drawing with measurements

To begin with, the shelf is composed of a single piece and therefore an injection in one go is possible which gives us an ahead for an easier implementation, the shape of the piece is simple and more suitable for injection. Above all, it is lighter than expected and has as a major asset to be able to fit together and therefore to assemble / disassemble quickly.

One of the complicated steps was to make sure that our piece was as aesthetic as possible since this product is intended for a childish audience, while respecting the maximum dimensions given by the company. The choice fell on rounded shapes, following the lines of the locations for the pots for more harmony. The grip is done on the sides of the tray, hand shapes have been drawn for a practical and aesthetic side also.

For the interlocking of the feet, the analysis of the existing was used for the realization. it was decided to make a system with a shoulder at the end of our feet. The margin left will be enough so that it is not a strong fit. In addition, the tips of the feet that will be used for assembly are stripped with two angles. One by a few millimeters with an angle identical to those of our interlocking holes. A second larger angle on the rest of the foot to further facilitate nesting. Finally, a hole at the exit of the feet has been added to allow air to escape easily and not to make a "suction cup" effect which would complicate the disassembly for a child

Standards

Given the fact that we are producing a product that its destined to the general use of the public we had to consider the following standards while designing our product: European Directive No.2009/48/EC consists of setting out the essential safety requirements applicable to toys, such as:

Physical and mechanical properties.

Flammability.

Chemical and electrical properties.

Hygiene and radioactivity.

The EN 71 standard sets that the toy must withstand the constraints linked to their use by a child and to be protected from the toxicity and flammability.

Results

Mechanical strength tests

To prove that our piece has the necessary characteristics, we had to carry out various studies.

SolidWorks simulation

Shifting

At most, the displacement will be 0.22 mm at the center of the part.

Deformation

From a deformation point of view, the maximum is 2.28e-04. The part can therefore support this load easily.

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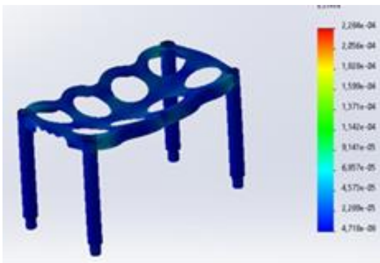


Figure 7

MoldFlow tests

Injection point

The first step was to determine the ideal location for the injection point. In our case, the optimum injection point is at the center of the plate.

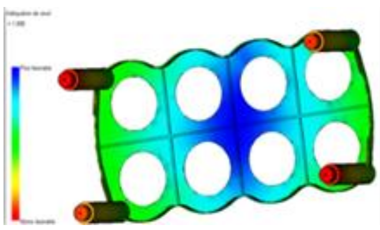


Figure 8

Filling time

Secondly, once our injection point has been placed, we must study the filling of our part. Fill time is 1.6 seconds. In addition, we can see that the part fills up in a balanced way including the feet.

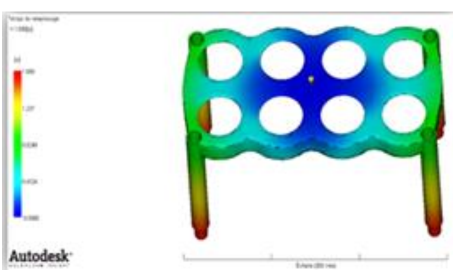


Figure 9

Switching pressure

Studying the switching pressure allows us to know the pressure that will be present inside the cavity when the machine will pass from the dynamic phase to the static phase: 390 bars.

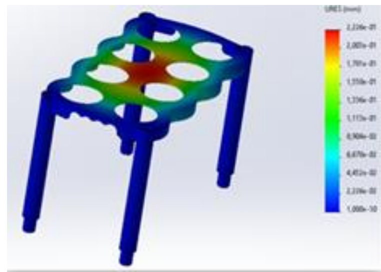


Figure 10

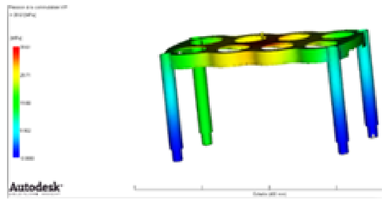


Figure 11

Pressure at the end of filling

The pressure at the end of filling allows us to know the pressure that will be there when switching to cooling: 310 bars.

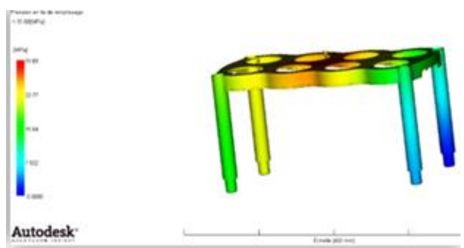


Figure 12

Weld line estimate

The estimate of the weld lines allows us to see where they will be located. Since our part has several holes (pots, interlocking, etc.), we will necessarily have welding lines.

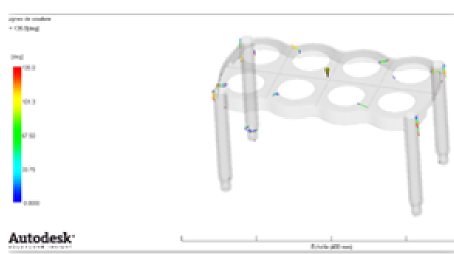


Figure 13

Flow front temperature

The temperature at the flow front complements the previous study. Indeed, we have the presence of a large number of weld lines but our material will have a temperature of around 220°C where the weld lines are most critical.

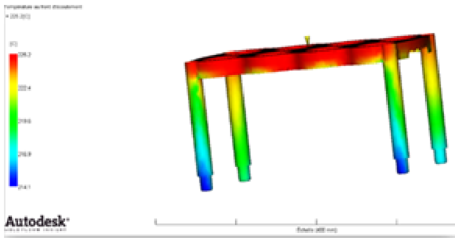


Figure 14

Warping

The legs retracted inwards by 6mm which was not acceptable given that we have an assembly.

Our first job was to reduce this warping, we noticed that the displacement increased according to the length of the legs. We have concluded that if the board no longer flexes, the legs will remain in their positions.

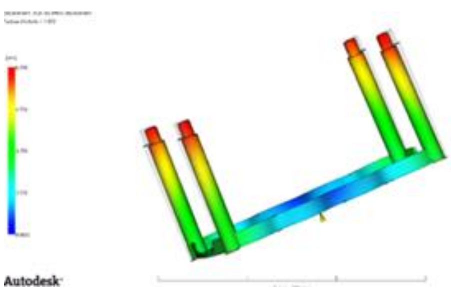


Figure 15

In addition, we standardized the thicknesses because we had big changeset at the start.

Finally, we relaunched a study and with these modifications we have a warping of 0.44mm maximum which is largely acceptable knowing that we have more than 2mm of margin in the interlocking of the legs.

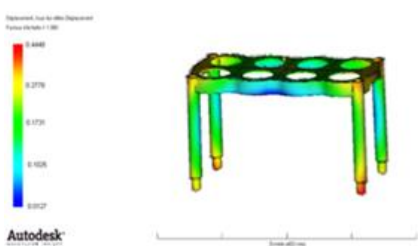


Figure 16

Costing and manufacturing method

Locking force required:

To choose the press that will accommodate the mold and ensure this production it is necessary to know what locking force is necessary.

The projected area is about 442.5 cm2 and a pressure in the footprint of 420 bar. A locking force of 230T is therefore required.

Tooling costs:

The tooling cost includes the study price, supplies, and the manufacturing price as well. Adding all these costs the price of the tooling is 4500 €. On the other hand, a simulation on the HASCO site was carried out and we arrive at a tooling price of about 6500 € which seems more plausible given the dimensions of our mold which are still quite large.

Calculation of cycle time:

The calculation of the cycle time is important to be able to calculate later the theoretical cost price of our part. This is 26 seconds considering the injection time, cooling time, holding time and empty cycle time. The cooling time was established thanks to the CATIC diagram, it is 12 seconds.

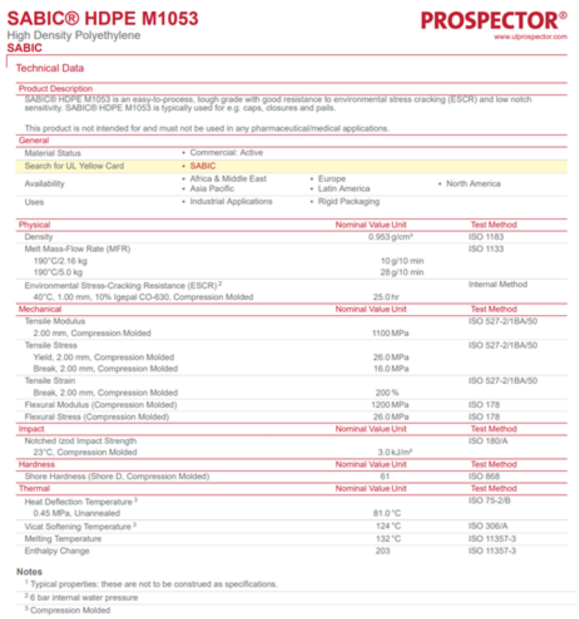
Theoretical cost price piece:

The theoretical cost price will make it possible to know how much a piece will cost to produce, knowing that in our case it takes two pieces to make a shelf. For this, the depreciation of the production was taken into account, the cost of a launch, the cost of molding and that of the material.

The depreciation is 1.81€. The cost of material per piece is 0.179 €, knowing that pfor the material we started on a price of 1400 € / T (which is very variable at the moment) and that our mold is 128g. The launch cost is 0.15€, the molding cost is 0.33€.

Finally, thanks to this data we deduce a theoretical cost price of € 2,469 per piece.
Knowing that our shelf must have two floors we only have to multiply it by two to obtain the theoretical cost price of our final product which will be 4.938 €.

Annexes



SABIC® HDPE M1053
High Density Polyethylene
SABIC

PROSPECTOR®
www.ulprospector.com

Technical Data

Product Description

SABIC® HDPE M1053 is an easy-to-process, tough grade with good resistance to environmental stress cracking (ESCR) and low notch sensitivity. SABIC® HDPE M1053 is typically used for e.g. caps, closures and pails.

This product is not intended for and must not be used in any pharmaceutical/medical applications.

General			
Material Status	• Commercial: Active		
Search for UL Yellow Card	• SABIC		
Availability	• Africa & Middle East • Asia Pacific	• Europe • Latin America	• North America
Uses	• Industrial Applications	• Rigid Packaging	

Physical	Nominal Value Unit	Test Method
Density	0.953 g/cm³	ISO 1183
Melt Mass-Flow Rate (MFR)		ISO 1133
190°C/2.16 kg	10 g/10 min	
190°C/5.0 kg	28 g/10 min	
Environmental Stress-Cracking Resistance (ESCR) [2]		Internal Method
40°C, 1.00 mm, 10% Igepal CO-630, Compression Molded	25.0 hr	
Mechanical	**Nominal Value Unit**	**Test Method**
Tensile Modulus		ISO 527-2/1BA/50
2.00 mm, Compression Molded	1100 MPa	
Tensile Stress		ISO 527-2/1BA/50
Yield, 2.00 mm, Compression Molded	26.0 MPa	
Break, 2.00 mm, Compression Molded	16.0 MPa	
Tensile Strain		ISO 527-2/1BA/50
Break, 2.00 mm, Compression Molded	200 %	
Flexural Modulus (Compression Molded)	1200 MPa	ISO 178
Flexural Stress (Compression Molded)	26.0 MPa	ISO 178
Impact	**Nominal Value Unit**	**Test Method**
Notched Izod Impact Strength		ISO 180/A
23°C, Compression Molded	3.0 kJ/m²	
Hardness	**Nominal Value Unit**	**Test Method**
Shore Hardness (Shore D, Compression Molded)	61	ISO 868
Thermal	**Nominal Value Unit**	**Test Method**
Heat Deflection Temperature [3]		ISO 75-2/B
0.45 MPa, Unannealed	81.0 °C	
Vicat Softening Temperature [3]	124 °C	ISO 306/A
Melting Temperature	132 °C	ISO 11357-3
Enthalpy Change	203	ISO 11357-3

Notes
[1] Typical properties: these are not to be construed as specifications.
[2] 6 bar internal water pressure
[3] Compression Molded

Acknowledgment

I would like to thank both of my participating universities in the process of this study, which are the University of Savoie Mont Blanc and the Technological University of San Juan del Rio. As well as the teachers and classmates who guided me during the process of succeeding this investigation.

Conclusion

This project has continued to evolve over time with new design ideas to ensure that the product meets the specifications. The idea of general design with the interlocking of our trays generated some problems that we had not thought of. The phenomenon of warping of the feet was the most complicated problem to solve and the help of professional helped greatly. Some points of improvement are always possible, especially at the aesthetic level it would be necessary to improve the design of the shelf with decorations, color, attractive elements for children. At the level of the forms and given the general idea, it was complicated to make a childish conception.

In the end, the project respects the specifications provided by the company (dimensions, number of trays, pots). As for the price, it had to represent 60% of the total selling price of the shelf, knowing that it is between 12 and 18 €. The theoretical cost price is 4.938 € which is in line with expectations.