EcoDesign

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FPT Sustainability Framework Masterclass

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Learning Outcomes

#FPSS22

- What needs to be considered when designing?
- And for eco design?
- Techniques
- Stakeholder Engagement
- Case Study-Injection Moulding
  - Material Selection
  - Wall Sections
  - Carbon Footprint And Processing Energy Requirement

Focus

- Design
- Stakeholder Engagement

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Design and Consideration for

- Environment
- Embedded carbon
- Recyclability
- Recycled Content
- Transport efficiency
- Product eco-design techniques
- Longevity
- Energy Efficiency

Design and Consideration of the Environment

- During product or packaging design, the environmental impact should be considered at every stage in the life-cycle, from the raw material extraction through to the end of the product’s life.
- Designers already do this when considering form or function; for example, a common design question is “how strong does packaging need to be to transport the product safely from the manufacturer to the consumer?”. It is therefore only a small step for businesses to start to consider the life-cycle from a wider sustainability point of view.

Reading Reference: http://bpf.co.uk/eco-design

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Design and Consideration of the Environment

- For example, when manufacturing a mobile phone and looking at the consumer behaviour, we can see that it is often only used for twelve to eighteen months before it is replaced. Therefore, one of its biggest impacts would be disposal (which can be minimized by designing the phone for ease of recyclability), so a mobile phone company might want to examine the amount and mixture of materials from which it is made to help minimize any impacts associated with its dismantling and disposal. During the 'eco-design' process the company would need to consider its manufacturing using as little (and as few) materials as possible. If the phone is compared to the mobile phone charger, the biggest environmental impact of this is almost definitely the amount of energy expended during its usage. It would therefore be sensible to 'eco-design' the phone charger by trying to optimise the energy efficiency during usage.
- The Design Council recently estimated that 80 % of the cost of a product is set at the design stage , and therefore reducing the environmental impact of any product during the concept design is actually the most beneficial stage at which to make cost savings.

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Design for embedded carbon

- Look at the material used in the product or its packaging; for example, using ABS that is made from 60% recycled content can reduce the product’s embedded carbon by up to 50%.

Design for recyclability

- Consider the recyclability of the materials from which the product or packaging is made.
- Minimize the different types of materials used and, if possible, move to a single material product.
- Look at how the materials are fixed together; for example, moving from screws to snap clips reduces the amount of time it

 takes to dismantle the product and they could also be made from the same material.

Design for recycled content

- Most modern materials can include high levels of recycled content, for example cardboard boxes, metals and most plastics.

  An obvious and commonly-used example are water drinking bottles, one of the first to be made from 100% recycled PET.

- By asking suppliers for more recycled content in the materials purchased, costs can often be cut and money can be saved.

Design for transport efficiency

Can the packaging be designed so that more products fit onto one pallet?

- Can the packaging be designed to interlock or stack in a different way to allow more products to stack together?

- Can shelf-ready packaging be introduced, thus eliminating the need for secondary and transit packaging and therefore fitting more products together in one pack?

Product eco-design techniques

Design for concentration

- If a product contains water, for example cleaning products, paints, coatings or drinks, can it be concentrated so the consumer can mix it with water at it’s destination?

  this means smaller (and cheaper) packaging, lower transport and storage costs and sometimes a longer lifespan of the product

Design for longevity

- Historically, some companies have been accused of planned obsolescence, which is deliberately planning or designing a product with a limited useful life, so that it will become obsolete or nonfunctional after a certain period to ensure consumers re-purchase products

Design for energy efficiency

Products that use energy are starting to be covered by new regulations (under the European Energy Using Products Directive) which set out eco-design requirements, mostly to do with energy efficiency in use. Therefore, manufacturers are starting to have to document and reduce the energy used in standby, on and powered-down modes

Design and Consideration for

- Environment
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- Recyclability
- Recycled Content
- Transport efficiency
- Product eco-design techniques
- Longevity
- Energy Efficiency

Stakeholder Engagement

All of the above can (and should) be considered during the design stage of any product or packaging. A good way to do this is to undertake a workshop, inviting representatives from all the different sections of the business, from marketers, production managers and environmental managers to the senior management to attend and contribute. Brainstorming with these different staff together, looking at product lines as specific examples and building short, medium and long term plans for improvements, quite often identifies projects where low cost / no cost changes can save vast amounts of money. It is worth remembering that, although external consultants can often add value by providing additional advice and expertise and by helping to facilitate the workshop discussion, no-one knows a company better than its own staff!

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Case Study

- Materials
- Wall Sections
- Carbon Footprint
- Processing Energy

Carbon Embedding-Injection Moulded Product design

Material Selection

- Consider the possibility of using a 100% recycled material feedstock – only those with manufacturer's technical data sheets!

- Consider the amount of energy required to melt process and cool the moulded component polymer, eg:

  PP exhibits a specific heat of 2790 J/KgK and a heat removal requirement of 670 J/g of shot weight

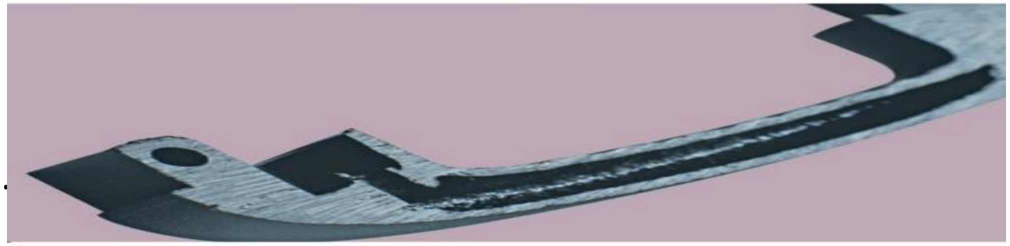
  Whereas

  ABS exhibits a specific heat of 2050 J/KgK and a heat removal requirement of 369 J/g of shot weight

- Consider the possibility of using an uncoloured or clear plastic to mould the intended component, thus increasing the 'second hand' recycled value of the product material at its end of life. Eg, 'Jazz PET' scrap is worth considerably less than clear PET bottle scrap.

- Consider the injection moulding technique, eg, Gas assisted (Cinpres or Mucel) moulding techniques use considerably less polymer than solid wall sections with the bonus of faster moulding cycle times.

Gas injected hollow handle injection moulded component.



Carbon Embedding-Injection Moulded Product design cont'd

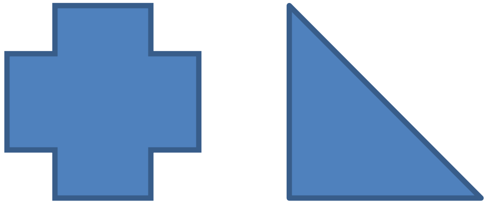
Wall Sections

Embedded Low Carbon considerations:

Avoid the following design features:

- Sudden changes in wall section, eg. from 6mm to 2mm causing differential cooling – extended cooling times to avoid warping.
- Thick wall sections require longer cooling times, eg, 1mm thick PP requires 2.4 secs to cool
  Whereas
  3mm thick PP requires 25.5 secs to cool
- Melt accumulation features (hot spots) require longer cooling times and increase shot weights – wasting polymer.

  Thick features inside wall profiles hold heat and are difficult to cool. Cruciform features, where two ribs meet increase the the volume of polymer to be cooled. Joining ribs need to be designed using a 2/3 ratio, eg, a 2mm wall joining a 3mm wall removes the 'Hot Spot'. Do not use a triangular section.



- Calculate a minimum wall section requirement fit for purpose, eg, A wall of PP 3mm thick is weaker than a wall of Acetal (POM) 1mm thick.

Carbon Embedding-Injection Moulded Product design cont'd

Polymer processing machinery can use large amounts of electrical energy during use, eg, a 40 Tonne clamp force hydraulic machine typically uses 23 Kwh, whereas a 500 Tonne machine can typically use 150 Kwh. It is therefore more energy efficient to reduce cycle times and only cool the thinnest polymer wall sections required to do the job. Calculation of a Polymer Wall Section Cooling Time:

Estimation of an injection moulded component cooling time t (seconds)

Using the Fourier Equation: $t = \frac{Fo\,H^2}{\Upsilon}$

Where: Fo = Fourier Number

H = Half the wall thickness (M)

Υ = Diffusivity ($10^{-7}\ m^2\ s^{-1}$)

In order to find the Fourier number the dimensionless number Θ is required.

$\Theta = \frac{Te - Tm}{To - Tm}$

Where Te = Ejection Temperature

Tm = Mould Temperature

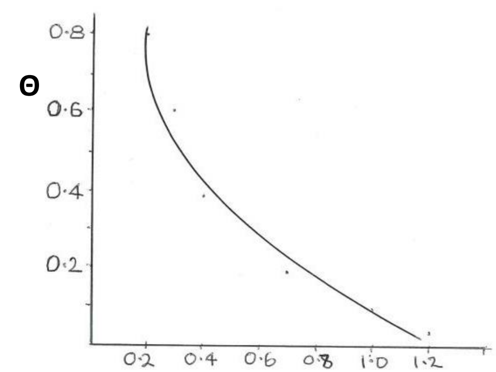
To = Melt Temperature

Example: For an ABS component with a wall thickness of 3mm (thickest section)

Te = 60°C, Tm = 40°C, To = 240°C $\quad \Theta = \frac{60 - 40}{240 - 40} = 0.1$

Using the Fourier curve for a Θ value of 0.1 the fourier number is 1.

$$t = \frac{Fo\,H^2}{\Upsilon} = \frac{1 \times (0.0015^2)}{0.9 \times 10^{-7}} = \underline{25 \text{ seconds}}$$



Carbon Embedding-Injection Moulded Product design cont'd

Calculation of Wall Thickness

The wall thickness of an injection moulded component is generally calculated from the flow-ability of the polymer resin. Flow ratio's for different polymers based upon a 1mm wall section:

Polymer	Flow Ratio for 1mm wall Higher Mw	 Lower Mw
ABS	80	150
Acetal (POM)	100	260
Polycarbonate (GP Grade)	30	80
Polypropylene	150	350
Nylon 6	140	360

Wall thickness calculation example:

For a 300mm end gated plastic ruler > moulded in a low Molecular weight (Mw) Polycarbonate the wall thickness is (300 ÷ 80) = 3.75mm

Alternatively,

If moulded in a low Mw grade of ABS the wall thickness is (300 ÷ 150) = 2mm

(a considerable saving in polymer and processing energy)

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DFM – Carbon Footprint And Processing Energy Requirement

The production of 1 Kg of PET or LDPE requires the equivalent of 2Kg of oil for energy and raw material *(Source: Pusch, Thoma Umwelt 2009)***.**

Burning 1Kg of plastic creates approximately 3 Kg of CO_2. For every 1 Kg of polymer, about 6 Kg of CO_2 is produced as a result of production, conversion and incineration. It is therefore important to Recycle and not incinerate waste plastics.

The amount of energy required to melt process a polymer (Plasticize, Form then Cool) can be calculated.

Polymer	Melt Temp °C	Mould Temp °C	Temp Diff °C	Specific Heat J/KgK	Enthalpy to Cool J/g
PET	240	60	180	1570	283
ABS	240	60	180	2050	369
PC	300	90	210	1750	368
Nylon 6	250	80	170	3060	520
PP	260	20	240	2790	670
LDPE	200	20	180	2780	500

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DFM – Energy Calculation Cont'd

Calculation of required processing energy:

Example:

A 4 impression injection mould tool is running on a 30 second cycle making 40g ABS covers in a 110 T injection moulding machine. Calculate the energy to process.

Amount of polymer being processed :

$$\frac{(40\text{g of Polymer} \times 4 \times 2}{60} = 5.33\text{g/sec}$$

Amount of energy to plasticize = 5.33 X 369 = 1968 J/sec or 1.97 Kw

Based upon the following typical injection moulding machine energy rating values the processing energy efficiency can be estimated:

Clamp Rating Tonnes	20 T	60 T	110 T	140 T	175 T	250 T	375 T
Total Connected Power (KW)	12.2	23.3	33.2	45	50	65	134

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Sustainability Framework

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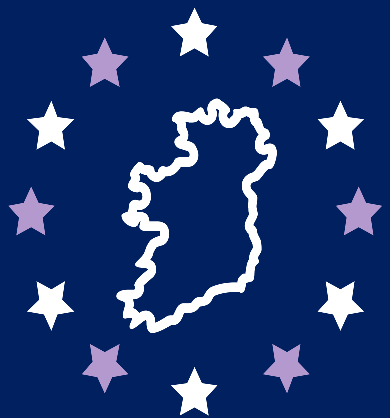
Q&A



Thank you
Go Raibh Maith Agaibh
Please Get in Contact

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