

Development of a Commercially Viable Product



Assignment 1: Dissertation

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Submitted to Mr Richard Morgan,

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'This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.'

Signed: Mr A. Hillam

Date: 24/04/2018

Executive Summary

This report details an engineering design project. The goal of the project is to design and manufacture a dog bed which improves the dog and its owners sleep quality whilst providing a simplistic method of assembly, it also needs to be easy to clean, robust and low cost. This project stems from personal experience of owning dogs and observing various behaviour patterns this has further been reinforced by other dog owner's experiences.

Research was carried out to understand the impact that low quality sleep has on humans and dogs. It was determined that the hippocampus which is responsible for short term memory to be stored and processed, and Spatial awareness was affected which results in confusion and an inability to learn efficiently. It was also determined that severe sleep deprivation also results in an increased risk of diabetes, weight gain and other health problems.

To facilitate an effective and successful design, a comprehensive list of customer requirements was transformed into quantitative engineering specifications. For the purpose of the design process. The primary aspects resulting from the specification consist of; lightweight, robust, safe, affordable and easy to sanitize. Throughout the design process, both the requirements and their corresponding specifications have been re-evaluated and redefined.

The design process has been is detailed throughout this report, which include methodology, procedures, analyses, and end results. A detailed description, including finalized CAD models of all components is provided as well. The design has been modified throughout the process to help improve the results and the current design is the result of intense engineering efforts and analysis. This report document the design process from initial background research to final recommendations for improvement to the final design.

This report documents the entire design process consisting of the measures taken to ensure that all established customer requirements and engineering specifications have been validated and satisfied in preparation of the final prototype, the final manufacturing plan, a detailed description and analysis of every component, a depicted description of the functionality of the product and the components, and finally, recommendations which could help improve the final design and suggested future work.

Contents

1. Figures / Tables	5
2. List of Abbreviations	6
3. Gantt	7
4. Introduction	8
5. Project Aims	9
6. Background Research	10
i. Medical Understanding	10
ii. Dog effect on human sleep requirement	11
iii. Preliminary market research	12
iv. Current products	13
7. Product Design Specification	20
8. Methodology	24
9. Primary Design	25
10. Non-destructive Testing	31
i. Stress analysis	31
ii. Buckling analysis	35
11. Production Strategy	36
12. Market Research	37
13. Conclusion	38
14. References	40
15. Appenix	43
i. Customer concerns	43
ii. Material data	47
iii. Case study	57

Figures / Tables

1. Figure 1: Pop-up tent	13
2. Figure 2: Collapsible pet carrier	14
3. Figure 3: Electric pet blanket	15
4. Figure 4: Pet cage	16
5. Figure 5: Hooded bed	17
6. Figure 6: Corner column	25
7. Figure 7: Spine	26
8. Figure 8: Support arm	26
9. Figure 9: End cap	27
10. Figure 10: Polyamide fabric	27
11. Figure 11: Polyamide mesh	28
12. Figure 12: product as a column	29
13. Figure 13: Product part assembled	29
14. Figure 14: product fully assembled	30
15. Figure 15: Column stress	31
16. Figure 16: Spine stress	32
17. Figure 17: Direct spine stress	33
18. Figure 18: Support arm stress	33
19. Figure 19: Column buckling	34
20. Figure 20: Spine buckling	35
21. Figure 21: Support arm buckling	35
1. Table 1: Gantt chart	7
2. Table 2: Market value	12
3. Table 3: Customer specifications	20
4. Table 4: Force table	21

List of abbreviations

CAD	-	Computer Aided Design
FEA	-	Finite Element Analysis
CAE	-	Computer Aided Engineering
PDS	-	Product Design Specification
NDT	-	Non-Destructive Testing
CFD	-	Computational Fluid Dynamics
DMADV	-	Six sigma – creating a new product or design process
DMAIC	-	Six sigma – improving an existing business process

Gantt



Table 1: Gantt Chart

Introduction

The purpose of this project is to identify problems concerning dog owners and develop a product that would mitigate the problems.

By using research methods consisting of observation of dog's behaviours, surveys with dog owners and literature, three common issues have been determined which involves dogs sleeping habits / arrangements.

The first concern consists of the dog disturbing the owners sleep by entering their bed, this is due to reasons such as owners endorsing it as a pup, the dogs are cold or anxious. Some owners try using cages with the hope that the dog will stay in its own bed, but this can prove difficult as it does not necessarily deal with the reasons in the first place, after observing dogs sleeping habits, it was determined that when a dog is at the right temperature they will sleep anywhere quite happily, however maintaining the heat can prove costly.

The second concern consists of dogs being placed in a boarding kennel. The kennels have small spaces, cold due to the concrete/plastered walls and open rooms and they are only heated by a heat lamp, which provides some heat but nothing ideal for house pets. The sight of boarding kennels is also disheartening to pet owners, knowing what conditions they will be in.

The third problem is the cumbersomeness of some pet beds, such as the dog crate / cage. The cages are very heavy and take a lot of time to disassemble and reassemble which proves very difficult for the elderly and disabled.

This document highlights out potential solutions to the problems concerned, by using various management techniques such as a product design specification (PDS), and an IDEO model which is used to help guide the product to meeting its end goal.

Project Aims

The aim of the project is to improve the conditions of a dogs sleeping habitat by developing a commercially viable product.

The outcome of the project should demonstrate the ability to formulate a problem-solving methodology by using engineering knowledge obtained within the mechanical and manufacturing engineering course. Specific outcome of developing a product should demonstrate the following:

- an innovative analytical mind-set
- an awareness of the business world
- product management
- project management
- resource management

The following tasks provide a guideline to develop and analyse potential solutions.

- Research the problem.
- Determine and implement a suitable methodology to help guide the product.
- Create a product design specification.
- Determine a suitable product to provide a solution.
- Identify suitable materials to use.
- Identify suitable manufacturing processes.
- Provide non-destructive testing analysis.
- Develop a prototype.
- Evaluate the product and solution

Background Research

Medical Understanding

In a report conducted by Mayo Clinic proceedings, it discussed people's perception of having pet dogs sleeping in the bedroom / on the bed, typically most dog owners expressed that having their dogs close by helped them to sleep / relax overnight, and the tests conducted showed that dogs sleeping in the bedroom did help improve sleep efficiency but a dog sleeping on the bed did increase sleep disturbances, further to this people expressed problematic disturbances caused by their dogs such as wandering, snoring, voiding needs, whimpering and seizures. (1)

The negative effects of sleep deprivation in both the pet owner and the dog is reduced function of the hippocampus. The hippocampus is the part of the brain which allows; short term memory to be stored and processed, and Spatial awareness which allows you to cognitively map your position. The result of reduced function causes both entities to become confused or/and not able to learn new things. (1) (2)

A recent study by "Annals of Internal Medicine" has compared weight gain and sleep deprivation, the study showed that during sleep deprivation, there is a rapid increase in the hormone "Cortisol" which typically helps to regulate body functions such as blood pressure, cardiovascular functions and helps break down fats, proteins and carbohydrates, Cortisol is commonly referred to as the stress hormone as it keeps the blood pressure stable and increases the metabolism to improve energy levels during stressful times. Because of the hormone increase, it builds up the appetite, but sleep deprivation also starts to reduce the function of mitochondria which allows your cells to absorb energy, as a result, sugar in the blood doesn't get used thus causing high blood sugars levels. The conclusion of the study determined that sleep deprivation could cause weight gain and diabetes. (3) (4)

Further to the hormone cortisol, when this hormone increases, it also requires an increase of other hormones such as thyroid, Oestrogen and testosterone, which can also lead to other health problems. (5)

Acute sleep deprivation, also affects contextual fear conditioning, which determines how an entity responds to fear. (i.e. A rabbit freezing or a dog cowering / lashing out). (6)

Dogs Effect on Human Sleep Requirements

For a person to get a good night's sleep there are a few conditions which should be considered.

- Temperature – The ideal bedroom temperature for an adult is 16 – 18°C, if it drops below 12 °C it can make it more difficult to fall to sleep, but if it goes above 24 °C it can cause restlessness.
- Lighting – when the room is dark it provides a better sleep environment, as the body releases melatonin which helps the person relax and fall to sleep.
- Comfort – the bed needs to be of a good texture and support, whilst providing enough room to stretch out. Lack of comfort can cause tiredness and aches.
- Noise – repetitive, sudden or loud noise causes sleep to be disturbed.

The conditions stated can all be affected by a dogs actions; if the dog gets into the bed it can increase the temperature causing restlessness, when a dog gets into the bed it reduces comfort as they take up room, they kick and scratch and they shed hair regular, when awake they can make disruptive noises such as whimpering and barking. These are a few conditions which then allows the lighting / melatonin to be affected, this is due to a lack of sleep at a preferred / ideal time. (7)

Preliminary Market Research

To ascertain the market value for dog beds, table 2 has been formulated, it focuses on the market sizes in the UK, EU (minus uk), USA and Canada. To evaluate the market size, the table considers:

- the pet dog population (this does not include strays)
- the dog owners, this determine how many dogs are in each household
- the industry size which ascertains the market value for dog products
- the market value for dog beds.

	UK	EU	USA	Canada	Total
Dog Owners	6.73M	32.15M	43.34M	2.40M	84.62M
Dog Population	8.66M	54.11M	69.92M	5.9M	138.60M
Industry Size	£10.6BN	£30.95BN	£51.03BN	£3.89BN	£96.47BN
Net Value of sold dog beds	£228M	£1.23BN	£4.94BN	£258,73M	£6.65BN

Table 2: Market Value

After considering the data accumulated on table 2, it is evident that there is a significant demand for dog beds. (8) (9) (10) (11) (12) (13)

Current products

The reasoning for designing the product is due to a few negative aspects with pet dogs, some of which consist of: cumbersome when relocating the dogs bed, dogs disturbing sleep and people's perception of their pet's comfort.

The primary considerations of the dog bed include light weight, ease to assemble / disassemble, reduce loss of heat and minimize the draught.

Secondary features include: low cost, lean manufacturing, recyclable, re-useable, easy to clean and resistant to various damage as a result to a dog's actions.

To help in the ideation of a functional product solution the following products have been analysed.

Pop-up tent



Figure 1: Pop-up tent

Figure 1, is a pop-up tent, it uses a linear wire spring for the frame and polyester for the fabric lining, the tent assembles using reactive forces to push the frame into its natural/desired state. Factors to take into consideration consist of the structural integrity of the frame, in case a dog jumps against or onto the frame, the fabric would also be selected to be more suitable to withstand a dogs biting, clawing, and hygiene elements such as defecation, urination and vomit. (14)

Collapsible pet carrier



Figure 2: Collapsible pet carrier

Figure 2, is a carrier crate designed for short term transportation, it is made using cylinder poles which connect, to form a cuboid frame, the fabric surrounding is made of two types of durable polyester, the frame collapses in one direction which results in a flat area. Factors to take into consideration consist of the structural integrity of the frame, in case a dog jumps against or onto the frame, the fabric would also be selected to be more suitable to withstand a dogs biting, clawing, and hygiene elements such as defecation, urination and vomit. (15)

Electric pet blanket



Figure 3: Electric pet blanket

Figure 3 is an electric pet blanket it consists of a durable vinyl pad which is heated directly, a fleece cover is also provided to create a comfy texture. After considering feedback on the product, the positive aspects consist of a pets attractive attitude to the product once warm, the negative aspects consist of a time delay when heating the pad, burning / smouldering of the fabric and fatigue of the protective covering of the wires. (16)

Pet Cage



Figure 4: pet cage

Figure 4 depicts a dog cage, the product is very durable against clawing, biting and is very easy to sanitise, it also provides an acceptable stress limit, as some buckling / dipping on the gates and roof can occur. The negative aspects consist of difficulty in assembly / disassembly of the product, the cages also typically exceed 12kg, which makes it very difficult to handle for the elderly and disabled. (17)

Hooded bed



Figure 5: Hooded bed

Figure 5 depicts a hooded pet bed. They consist of a fire-retardant foam for the interior and various aesthetic materials for the exterior appearance. The product is ideal to keep pets warm and they reduce pet's anxiety, the negative aspect of the product is that they block out external heat sources. (18)

When considering the products discussed above, the following summary has been created:

- Pop-up tent
 - **Advantage:**
 - Lightweight
 - Easy to assemble
 - Reduces draught
 - Compact
 - **Disadvantage:**
 - Blocks out heat source
 - Low yield stress
 - Susceptible to tears
- Collapsible pet carrier
 - **Advantage:**
 - Lightweight
 - Easy to assemble
 - Reduces draught
 - Compact
 - Does not block external heat sources
 - **Disadvantage:**
 - Costly
 - Low longevity
- Electric Blanket
 - **Advantage:**
 - The electric blanket can provide sufficient heat to keep dogs warm.
 - Does not need an external heat source
 - Light weight
 - Easy to setup
 - **Disadvantage:**
 - It only provides heat below the dog
 - It does not prevent a draft
 - Damage to the blanket could result in fatalities

- Dog cage
 - **Advantage:**
 - The cage can be compact
 - With additional blankets the cage can provide a draft block
 - **Disadvantage:**
 - Very heavy
 - Has no heat source
 - Can block off external heat sources
 - Difficult to setup
- Hooded pet bed
 - **Advantage:**
 - blocks draft
 - light weight
 - no setup required
 - **Disadvantage:**
 - Does not provide a heat source
 - Blocks off external heat source

Product Design Specification

Customer requirements

Based on discussions with dog owners and contacts working in the pet industry, it was possible to determine the following list of customer specifications, which are shown in order of importance from 5 (most important) to 1 (least important). Table 3, also includes the target values for the corresponding engineering specifications.

Customer Requirements	Importance (Low 1 - 5 High)	Engineering Specifications	Target Value
Easy to adjust	4	Adjustment time	<5 mins
Safety	5	Safety factor	110%
Affordable	3	Manufacturing cost	<£15.50
Easy to sanitise	3	Cleaning time	<10 mins
Longevity	2	service life	5 years>
Comfy	2	Comfortable usage time	8 hours
Aesthetics	1	Human interaction time	<5 mins

Table 3: Customer Specifications

Product Design Specifications

Following market research and ideation it has been determined that a new type of dog bed should be developed to exploit a potential gap in the market by mitigating current problems that occur with pet dogs, a PDS was produced to identify expectations for the final product.

A. Product design & performance issues...

This specification covers the general operational characteristics of the product and provides an overview of the requirements for the finished product.

1.0 Function

- 1.1 The product must reduce the draught in the sleeping area.
- 1.2 The product must be easy to assemble / disassemble.
- 1.3 The product must be lightweight i.e. below 10kg.
- 1.4 The product must not inhibit external heat sources.

2.0 Appearance

- 2.1 The product must be aesthetically pleasing to the customer.

3.0 Reliability

3.1 The product must be able to withstand the following forces shown in table 4,

Size	Weight (kg)	Max Speed (m/s)	Force (N)
Toy	5.4	12.5	67.5
Small	11.34	17	192.78
Medium	22.68	18.89	428.42
Large	45.36	20	907.2
X-Large	45.36+	20	907.2+

Table 4: Force table

3.2 A durable material needs to be selected for the walls which can withstand biting and clawing.

3.3 A durable material needs to be selected for the frame which can withstand biting and biting.

3.4 The product must last a minimum of 5 years before significant deterioration occurs.

4.0 Environment

4.1 Product will be used indoors temperatures varying between 12 – 30 °C.

4.2 The product will be exposed bodily residue left by dogs.

4.3 Humidity varies between 30% - 70%.

4.4 Contaminants can consist of faeces, vomit, urine, mud, dirt, hair.

5.0 Production Cost

5.1 The end-user cost for the UK, should be aimed at £50 per unit.

5.2 The cost to manufacture per unit should not cost more than £12

5.3 The cost of packaging and shipping per unit, should not exceed £3.50

6.0 Ergonomics

6.1 The product entrance must be suitable for a dog to enter.

6.2 Assembling / disassembling method should be designed for ease of the dog owners.

7.0 Quality

7.1 All manufacturers and manufacturing processes must comply with ISO 9000.

7.2 The product size must be suitable for a dog to sleep in, in accordance to animal welfare (licensing and activities involving animals) (England) regulations 2018. (19)

7.3 The product should last at least 5 years before significant deterioration occurs.

8.0 Process

8.1 The final prototype must be suitable to manufacture using the facilities available at the university which includes: 3D printing, laser jet cutting, water jet cutting.

8.2 Each component will be fully formed with fixing holes in place.

8.3 Each component will have a formed tooling unless pre-manufactured components can be sourced.

9.0 Materials

9.1 Selection of the materials and their use in the product must be in accordance with EU regulations.

9.2 The material selection must not be toxic or cause any negative health effects to dogs and their owners.

9.3 The materials used must be able to be sanitized using standard cleaning products.

10.0 Assembly

10.1 The assembly process will be fulfilled before the product reaches the customer / retailer.

10.2 The product will be manufactured to prevent tampering.

10.3 Assembly should take no longer than 10 minutes.

11.0 Packaging

11.1 The product will be bound tight prior to packaging.

12.0 Quantity

12.1 Initial launch would require 100 units to assess the demand.

12.2 If annual demand is less than 1000 units, quantity will stay at batches of 100.

13.0 Use

13.1 The product will allow dogs to sleep more efficiently whilst reducing anxiety.

13.2 The product will be easy to transport to various locations.

14.0 Maintenance

14.1 The product must be easily sanitized using standard cleaning products.

14.2 Instructions would be provided to show how to effectively maintain / clean the product.

15.0 Safety

15.1 Safety concerns consist of entrapment during assembly / disassembly function.

15.2 Excessive loads on the frame could result in structural failure.

16.0 Inspection

16.1 Visual inspections will be performed on each component during assembly.

16.2 1 unit out of every 100 will be tested to confirm standards are maintained.

17.0 Testing

17.1 Compressive stress tests will be performed on each component to assess how much force can be applied before failure.

17.2 FEA tests will be used to assess buckling effect under maximum force.

17.3 CFD tests will be used to assess heat transfer / effect on the product.

17.4 CFD tests will be used to determine air flow in and around the product.

17.5 FEA will be used to assess fatigue

17.6 Topology will be used to reduce waste material.

18.0 Patents

18.1 After searching the patent website “espacenet”, it has been confirmed that there are no patents that would infringe on the product outcome in this report.

19.0 Disposal

19.1 All components will be recyclable.

19.2 Components will indicate how it can be recycled.

19.3 Components should be easy to separate prior to recycling.

Methodology

To approach the design method systematically, the IDEO methodology has been adopted.

The process consists of the following steps: (20) (21)

- Empathy
 - What does the user care about?
 - Observe
 - Engage
 - Immerse
 - Uncover
 - Uncover the needs that people may not be aware of
 - Guide innovation efforts
 - Identify users to design for
 - Discover the emotions that guide behaviours
 - Empathy mapping
- Define
- Ideate
 - Brainstorming
 - Questions – How might we???
- Prototype
 - User prototyping
- Test
 - Show, don't tell
 - Ask users about the experience of the prototype
 - Watch, don't correct
 - Ask questions, answer questions

The IDEO model focuses heavily on what the customer valued the most by observing how they interact with various situations / products either directly and/or indirectly.

Primary Design

The following design description, is based on, the product designed for a medium sized dog.

Design Model: the frame design consists of 4 components which consist of:

- Corner Column – The corner column is a cuboid shape measuring at 600mm in height by 40mm by 40mm, it has a recess running down 2 faces with the 1st being perpendicular to the 2nd, the corner column will be made of polypropylene.

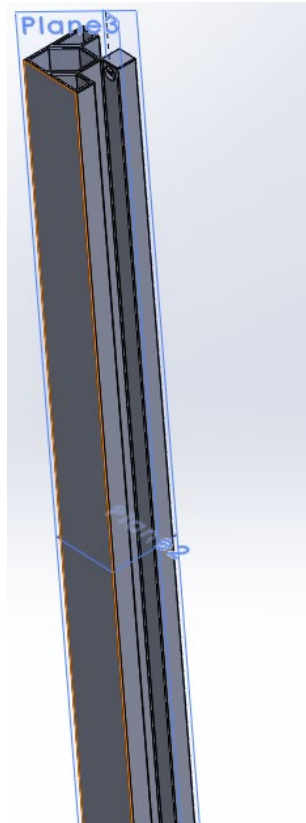


Figure 6: Corner column

- Spine – the spine is the column that runs parallel to the corner columns, the purpose of the spine is to connect the support arms from the corner columns, the spine will be made of polypropylene.

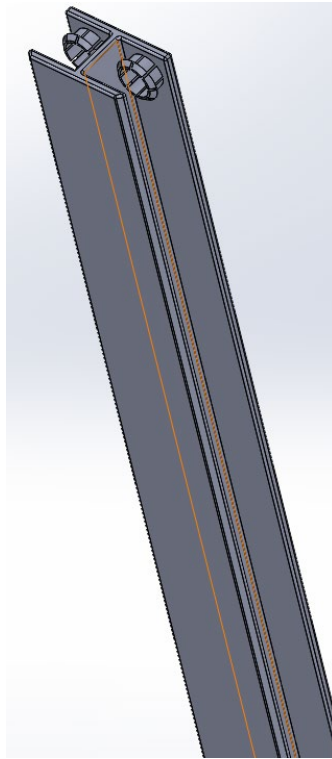


Figure 7: Spine

- Support Arms – the support arms are used along the bottom and the top of the frame as shown in figure 8, the support arms have 1 male and 1 female socket, the sockets are used to attach the support arms together and to the spine and/or corner columns.

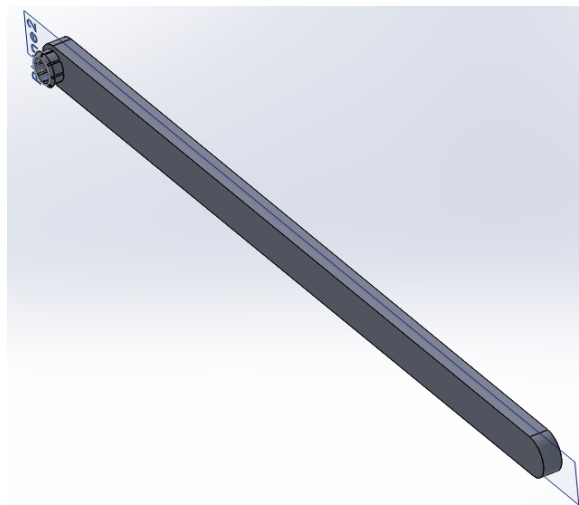


Figure 8: Support Arm

- End caps – the end caps are used to seal off the top and bottom sections of the corner columns, the end caps will also host the company logo.

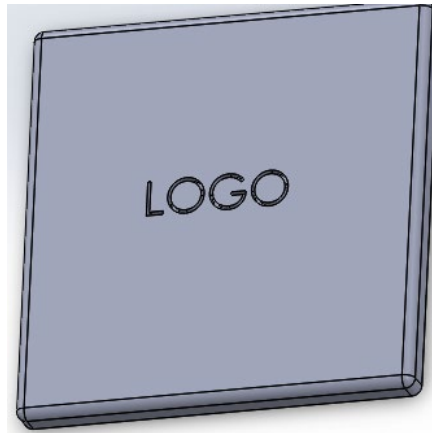


Figure 9: End cap

The fabric surrounding the frame will consist of the following fabrics:

- A 1mm thick polyamide fabric, will be used for the walls and roofing of the product, the material is highly resistant to tears caused by a dogs biting and clawing, the fabric is also resistant to mildew, stains, wrinkles and due to how tightly woven the fabric is, it makes it very easy to clean with typical house hold products.



Figure 10:polyamide fabric (22)

- A 1mm thick polyamide fabric will be used to form a mesh which will allow for heat sources to flow through into the products interior, the fabric can withstand temperatures of up to 215°C which makes it more than acceptable for the application to the product.

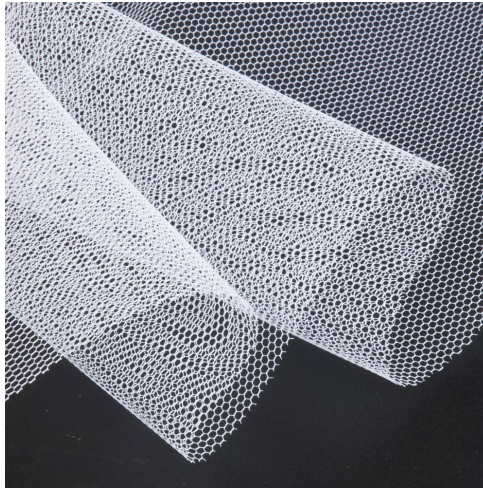


Figure 11: Polyamide mesh (22)

Design Function: Figure 12 depicts the product during its closed state as a column, the product volume has been reduced from 1030mm x 1030mm x 600mm to 92mm x 92mm x 600mm. This indicates a method of making the assembly / disassembly and transportation easier by further reducing the size of the product during transportation.

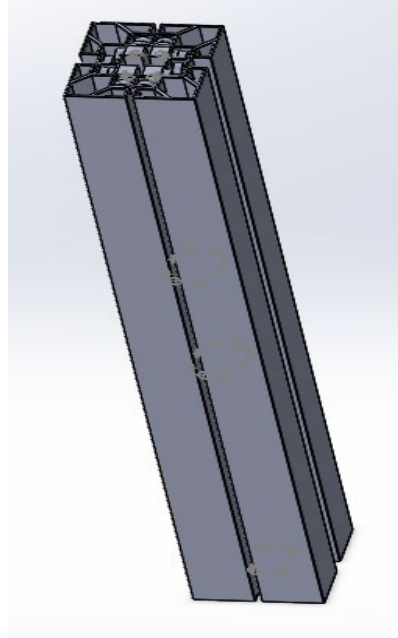


Figure 12: Product as a column

Figure 13 depicts the product at a semi state, which helps to illustrate the elbow joints which allows the products function of collapsing into a column possible.

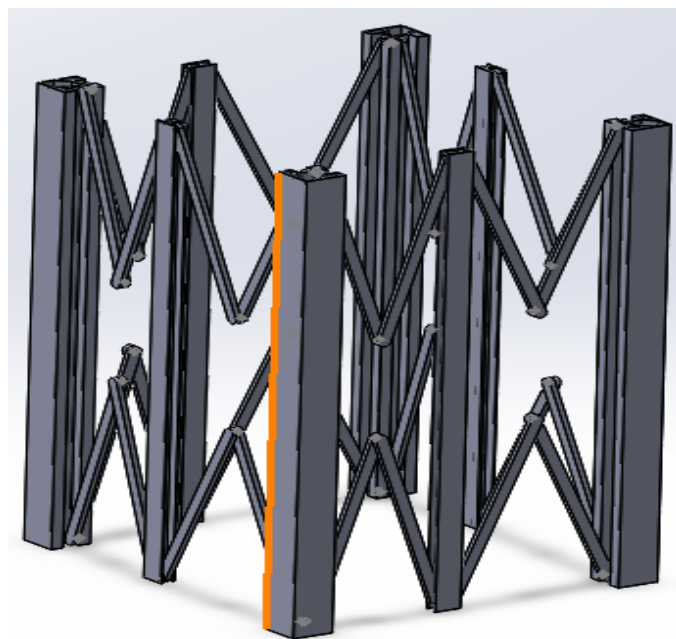


Figure 13: Product part assembled

Figure 14 depicts the product frame as it is fully expanded to its limits / assembled state, it shows how the volume of the product can be increased from 92mm x 92mm x 600mm to 1030mm x 1030mm x 600mm

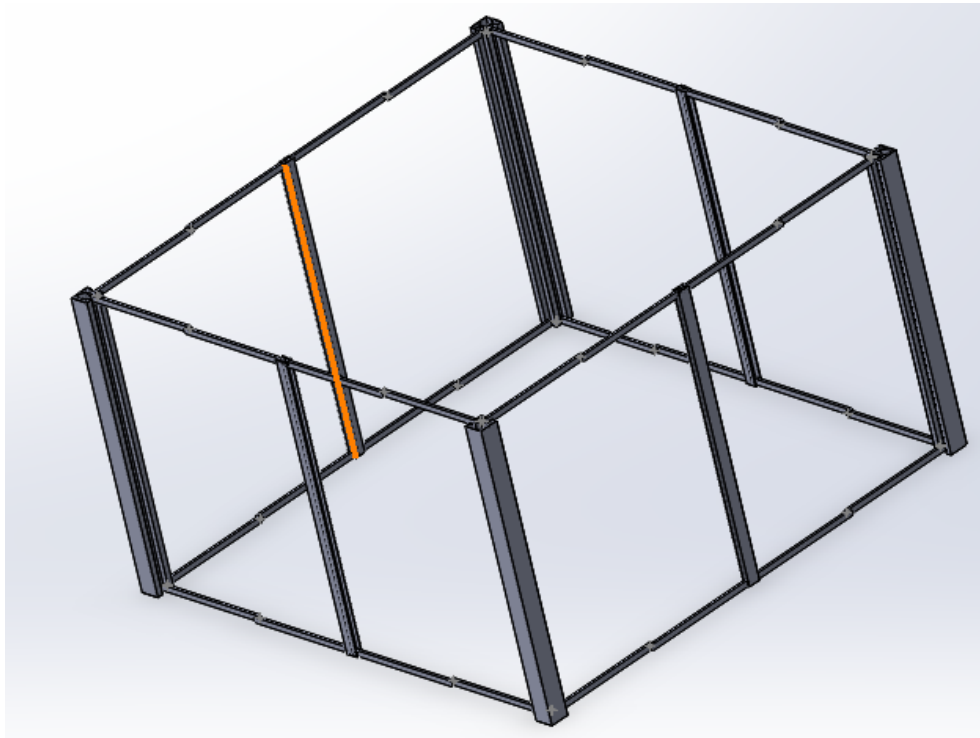


Figure 14: Product fully assembled.

Non-Destructive Testing

The following NDT methods have been analysed to verify the integrity of the product under potential circumstances.

Stress analysis

Column

Figure 15 shows the maximum displacement that could occur if a heavy-medium sized dog ran, at its maximum speed and directly hit the middle of the column, the result consists of 2.777mm displacement.

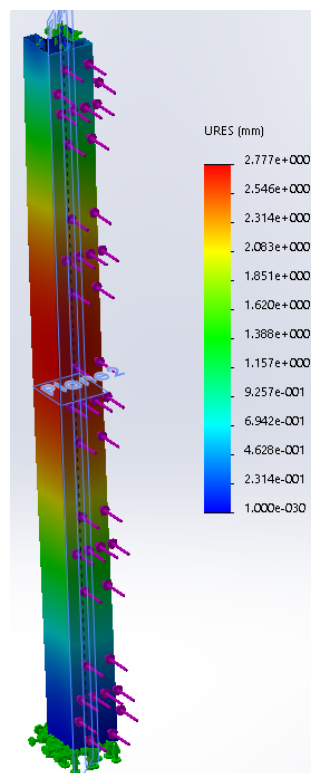


Figure 15: column stress

Spine

Figure 16 shows the maximum displacement that could be a result from a force of 430N that could be applied by a heavy-medium sized dog running at its maximum speed and hitting the top surface, the result consists of 0.426mm displacement, shown as red in the figure.

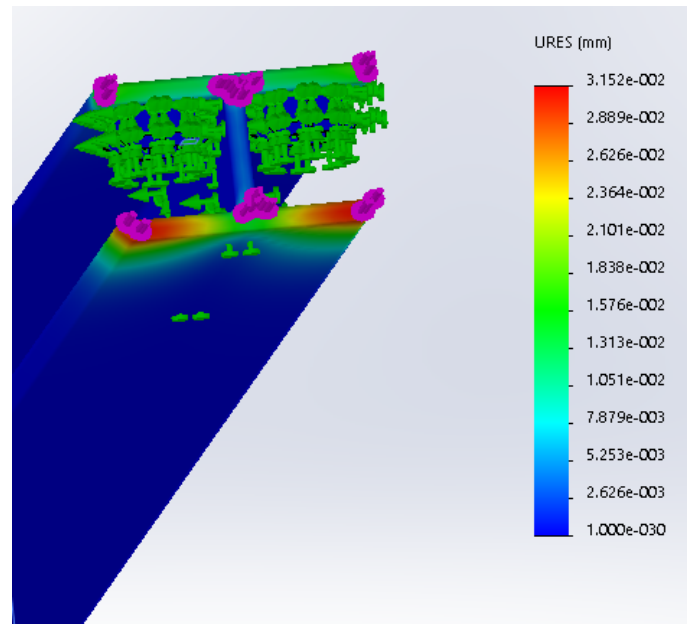


Figure 16: Spine stress

Figure 17 shows the maximum displacement that could occur if a heavy medium sized dog ran at the spine at its maximum speed, the worst circumstance consisting of the dog hitting the centre of the column which results in a displacement of 12.488mm.

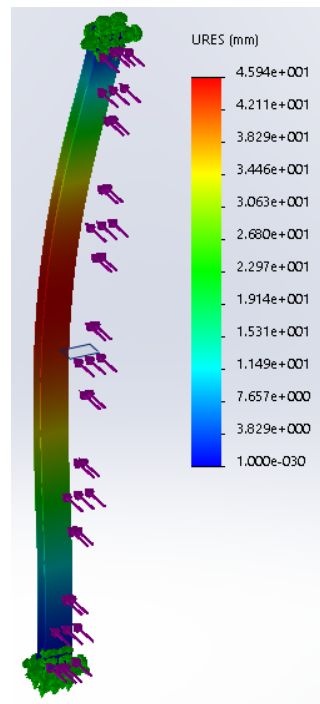


Figure 17: Direct spine stress

Support arm

Figure 18 features a support arm under a maximum force of 430N that could be applied if a heavy-medium sized dog ran at the support arm at its maximum speed, the result is a displacement of 13.98mm.

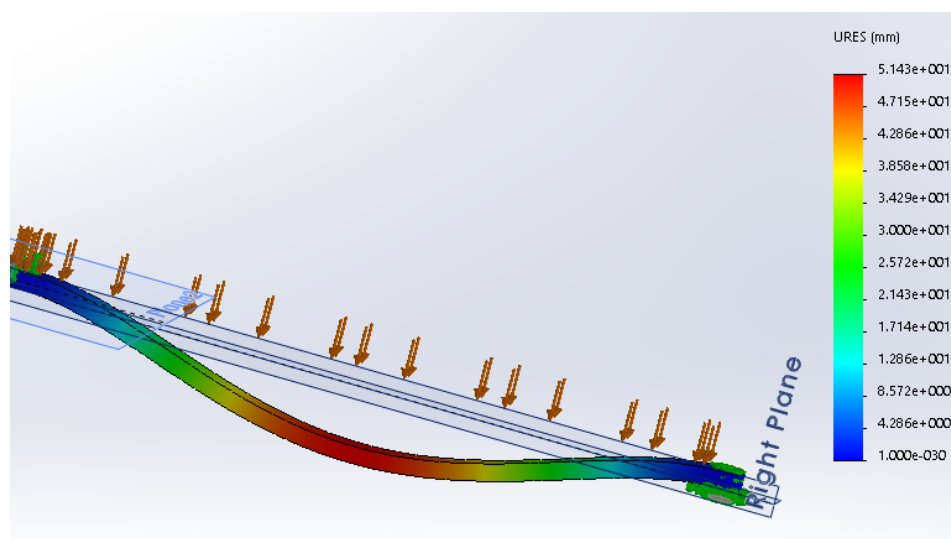


Figure 18:

Buckling

Column

Figure 19 shows the how the corner column could buckle if the maximum force of 430N was applied from a heavy- medium sized dog to the top surface.

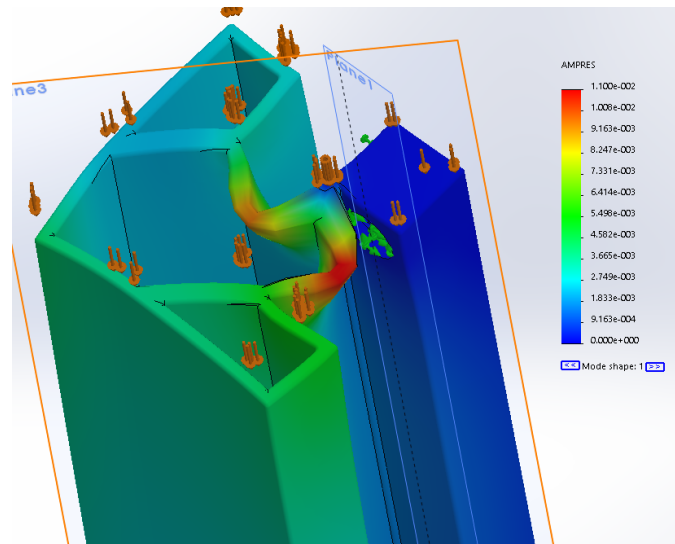


Figure 19: column buckling

Spine

Figure 20 shows how the spine could buckle if the maximum force of 430N was applied by a heavy-medium sized dog to the top of the spine.

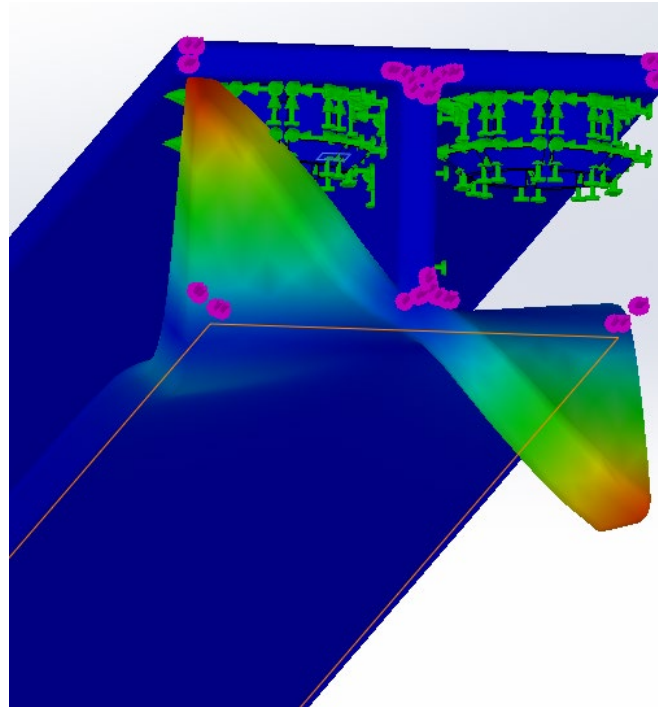


Figure 20: Spine buckling

Support Arm

Figure 21 shows the result of buckling that could occur if a heavy-medium sized dog applied the maximum force to the top of the support arm.

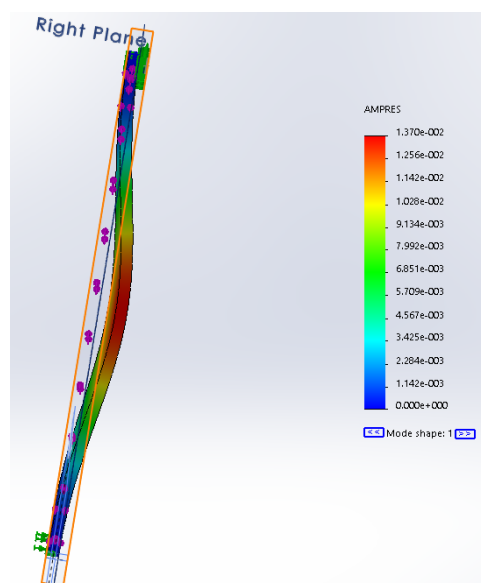


Figure 21: Support arm buckling

Production strategy

During the launch process, it is best to limit the amount of risk by reducing time and cost. The following steps focused on minimizing that risk.

Prototype – During the prototype phase, it would be more economical to acquire pre-fabricated polypropylene (offcuts) and machine them to fulfil the functional requirements. Although it is an expensive method and would not make the product as it stands a profitable venture, it is however an easy and quick method which will help to demonstrate the product to potential customers. (23)

Early launch – the early launch stage consists of a low volume of products in particular less than 100 units. These units will be used to help gauge the market and the demand. To make the production cost effective, it would be necessary to use a cheap tooling with an injection moulding method to form the polypropylene. (23)

Mass production – for the mass production stage, it is imperative to start reducing cost per unit, where ever it is possible to help maximise the profit out-turn, whilst remaining competitive. For this purpose, a high-quality tooling would be required during the injection moulding process using polypropylene, this would be the quickest and cheapest method to manufacture the high volume of components / units. (23)

Market Research

Potential customer base

Dog owners will typically buy the product either direct or through a retailer.

Potentially owners of other pets such as cats could also use the product.

After the creation of this product, it will allow the potential to create a recognised brand for future products.

Market constraints on product.

Recently there has been some related products launched

The current products can still be improved either by further reduction in cost, materials and improve functionality.

Conclusion

When considering the stress analysis on the various components, it has taken into account the force that could be produced from the heaviest dog, in the medium sized range, whilst running at the record speed for that range, the force value is actually over estimated as the heaviest dog in that range is not the fastest, this results in the maximum force of 430N not being possible. Although the stress analysis indicated that some displacement could be caused by the force, again it is impossible for the record speed, for that dog range to gain enough speed to apply the higher range of force.

The primary design section, determines that the product would be more than stable to support the designated dog size, due to the over estimation force values, it also can be considered as a factor of safety, the polyamide fabric makes it suitable for abrasions caused by dogs biting and scratching. The polyamide fabric and the polypropylene is able to help maintain sanitation of the product, not only do they offer a resistance to mildew and stains, due to their tightly compact structure, they also make it very easy to clean whilst using household cleaning products.

The functions of the product allow for it to be compacted into a column or fully assembled into a secure structure, due to the material used, it makes the product very lightweight when compared to other enclosed pet housing.

The polyamide mesh makes it possible to maintain external heat sources whilst the polyamide fabric walls reduce the draught.

To further improve the product design, the following sections could be implemented with the objective of either reducing cost, improving product analysis and reducing waste material.

Fluid flow and heat transfer would also be a valuable analysis to perform, in order to determine how the new product would benefit the dogs comfort.

Fatigue could be simulated using solidworks simulation professional. For the study, the fatigue analysis will focus on the joints between components and how they are affected over time from repeated use.

In order to speed up the design process, it would have been a better method to design it from an engineering method, using numeracy to determine the geometry requirement to fulfil the function of the product without any repercussions from stress and strain caused by external source.

Topology could be used to optimize the product by reducing all non-essential materials or improving the overall quality of the product.

Whilst polypropylene is factored in as the primary material for the frame, over time as recycled polypropylene becomes more common and affordable, it could be introduced as the primary material for the frame, to further reduce waste.

After the design phase has finished, it is important to ensure that the product remains in high demand, this can be achieved by adopting the six-sigma improvement process such as DMADV which follow the steps of;

- Define – the voice of the customer and demands
- Measure – evaluate the current processes, the product features and capabilities
- Analyse – determine other solutions to mitigate the problems
- Design – attempt to lock down the product such as poke yoke or prevention of competitive products by making the product as lean as it can be while maintaining the desired outcome.
- verify – ensure that desired quality level is maintained by running various tests such as NDT and physical testing.

By repeating the steps defined, it would be possible to reduce low quality items, improve the product performance, maintain the products integrity and ensure that the product thrives in a competitive market.

This report has focused on customer input/demands to help improve their own and their dogs' life style, this report also demonstrates that the product would be commercially viable

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Appendix

Customers Concerns

The customer concerns consist of various issues with regards to their pet dogs and sleeping habits.

Boarding Kennels	
Name: Ms T Mead	Dog: Beagle (lassie)
Concerns: When I take my dog to the kennels, I find it a struggle. The kennels are very noisy and dirty places, and it makes me upset when I have to leave lassie in that situation. Due to the environment, I like to make the kennel as nice as I can, so I normally take her cage with all of her bedding, just so it feels more like home.	
Requirements: When setting up lassies bed in the kennels, I find it very difficult as the cage is very heavy and takes time to dismantel and assembl it. I would prefer a bed that is more lighter and easier to put together, but still lets lassie stay cosy.	

Statement 1: Boarding Kennels

Bed Sharing	
Name: Ms S Bolam	Dog: Labrador (Mollie)
Concerns: When I got Mollie I bought her a nice big bed for her to sleep on, but when it gets to colder nights, she tends to come into my bed beneath the covers to stay warm. The problem is that she fidgets and keeps me awake which is causing other problems. The only way i can get Mollie to stay in her own bed is to keep the heating on, which also prevents me from sleeping due to the heat.	
Requirements: I would like a bed that will help keep Mollie warm at night which is still nice and compfy like the bed she already has.	

Statement 2: Bed Sharing

bed Sharing	
Name: Mr J Andrews	Alsatian (Logan)
Concerns: I didn't use to mind sharing my bed with logan as a pup, but he soon became much bigger, but now it is very difficult to get him to sleep elsewhere as he wont sleep unless he is undercovers.	
Requirements: I would prefer a product that gives logan a sense of security whilst giving him the impression of being in the bed.	

Boarding Kennels	
Name: Mrs A Dowle	Dog: Yorkshire terrior
Concerns: my concerns are with the boarding kennels, my little yorkshire terrior seems lost and very lonely, it is very disturbing leaving her there.	
Requirements: I would like an enclosed dog house which would make her feel more at home, it would make me feel much better knowing she is happy	

Cage Size	
Name: Mr B laws	Dog: Malamute (Dave)
Concerns: because of the size of dave, we bought him a metal cage, which he can use as his own home. The problem is when transporting it, due to the size of the cage, it has to be disassembled before we can fit it in the car and then we need to re-assemble it at our destination	
Requirements: I would like something that provides him with a home of his own, but I would like something that is easier to disassemble.	

Bed Sharing	
Name: Mr P Holmes	Dog: Collie (Casper)
Concerns: Casper is regularly filthy as he gets lots of exercise, the problem is he also likes lots of cuddle time in bed, but as you can imagine, he sheds a real lot of hair and dirt on our bed and furniture.	
Requirements: I would like something that casper can use as his own bed, rather than use ours but it needs to be easy to clean	

Material Selection

Polypropylene (PP)

Description

Image



Caption

1. Polypropylene samples showing texture and transparency. © Chris Lefteri 2. Polypropylene glasses. © Thinkstock

The material

Polypropylene, PP, first produced commercially in 1958, is the younger brother of polyethylene - a very similar molecule with similar price, processing methods and application. Like PE it is produced in very large quantities (more than 30 million tons per year in 2000), growing at nearly 10% per year, and like PE its molecule-lengths and side-branches can be tailored by clever catalysis, giving precise control of impact strength, and of the properties that influence molding and drawing. In its pure form polypropylene is flammable and degrades in sunlight. Fire retardants make it slow to burn and stabilizers give it extreme stability, both to UV radiation and to fresh and salt water and most aqueous solutions.

Composition (summary)

$(CH_2-CH(CH_3))_n$

General properties

Density	890	-	910	kg/m ³
Price	* 1.32	-	1.51	GBP/kg
Date first used	1957			

Mechanical properties

Young's modulus	0.896	-	1.55	GPa
Shear modulus	0.316	-	0.548	GPa
Bulk modulus	2.5	-	2.6	GPa
Poisson's ratio	0.405	-	0.427	
Yield strength (elastic limit)	20.7	-	37.2	MPa
Tensile strength	27.6	-	41.4	MPa
Compressive strength	25.1	-	55.2	MPa
Elongation	100	-	600	% strain
Hardness - Vickers	6.2	-	11.2	HV
Fatigue strength at 10 ⁷ cycles	11	-	16.6	MPa
Fracture toughness	3	-	4.5	MPa.m ^{0.5}
Mechanical loss coefficient (tan delta)	0.0258	-	0.0446	

Thermal properties

Melting point	150	-	175	°C
Glass temperature	-25.2	-	-15.2	°C
Maximum service temperature	100	-	115	°C
Minimum service temperature	-123	-	-73.2	°C
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.113	-	0.167	W/m.°C

Specific heat capacity	1.87e3	-	1.96e3	J/kg.°C
Thermal expansion coefficient	122	-	180	μstrain/°C
Electrical properties				
Electrical conductor or insulator?	Good insulator			
Electrical resistivity	3.3e22	-	3e23	μohm.cm
Dielectric constant (relative permittivity)	2.1	-	2.3	
Dissipation factor (dielectric loss tangent)	3e-4	-	7e-4	
Dielectric strength (dielectric breakdown)	22.7	-	24.6	1000000 V/m
Optical properties				
Transparency	Translucent			
Refractive index	1.48	-	1.5	
Processability				
Castability	1	-	2	
Moldability	4	-	5	
Machinability	3	-	4	
Weldability	5			
Eco properties				
Embodied energy, primary production	* 75.7	-	83.7	MJ/kg
CO2 footprint, primary production	* 2.96	-	3.27	kg/kg
Recycle	True			
Recycle mark				



Supporting information

Design guidelines

Standard grade PP is inexpensive, light and ductile but it has low strength. It is more rigid than PE and can be used at higher temperatures. The properties of PP are similar to those of HDPE but it is stiffer and melts at a higher temperature (165 - 170 C). Stiffness and strength can be improved further by reinforcing with glass, chalk or talc. When drawn to fiber PP has exceptional strength and resilience; this, together with its resistance to water, makes it attractive for ropes and fabric. It is more easily molded than PE, has good transparency and can accept a wider, more vivid range of colors. PP is commonly produced as sheet, moldings fibers or it can be foamed. Advances in catalysis promise new co-polymers of PP with more attractive combinations of toughness, stability and ease of processing. Mono-filaments fibers have high abrasion resistance and are almost twice as strong as PE fibers. Multi-filament yarn or rope does not absorb water, will float on water and dyes easily.

Technical notes

The many different grades of polypropylene fall into three basic groups: homopolymers (polypropylene, with a range of molecular weights and thus properties), co-polymers (made by co-Polymerization of propylene with other olefines such as ethylene, butylene or styrene) and composites (polypropylene reinforced with mica, talc, glass powder or fibers) that are stiffer and better able to resist heat than simple polypropylenes.

Typical uses

Ropes, general polymer engineering, automobile air ducting, parcel shelving and air-cleaners, garden furniture, washing machine tank, wet-cell battery cases, pipes and pipe fittings, beer bottle crates, chair shells, capacitor dielectrics, cable insulation, kitchen kettles, car bumpers, shatter proof glasses, crates, suitcases, artificial turf, thermal underwear.

Tradenames

Adpro, Amoco, Appryl, Aqualoy, Astryn, Cefor, Comalloy, Comshield, Dypro, EA36NA, Eltex P, Empee, Escorene, Ferrex, Ferrolene, Fortilene, Fotilene, Hifax, Hostalen PP, Latene, Marlex, Moplen, Multi-Flam, Multi-Pro, Nortuff, Novalen, Novolen, Nyloy, Petrothene, Polyfort, Polypro, Precolor, Pro Fax, Propak, Rexflex, Stamylyn, Starlylen, Statoil, Technoprene, Thermocomp, Vestolen, WPP, Washpen

Links

Reference
ProcessUniverse

Producers

Values marked * are estimates.

Polyethylene terephthalate (PET)

Description

Image



Caption

PET drinks containers, pressurized and unpressurized. © Tee design and printing Ltd

The material

The name polyester derives from a combination of 'Polymerization' and 'esterification'. Saturated polyesters are thermoplastic - examples are PET and PBT; they have good mechanical properties to temperatures as high as 175 C. PET is crystal clear, impervious to water and CO₂, but a little oxygen does get through. It is tough, strong, easy to shape, join and sterilize - allowing reuse. When its first life comes to an end, it can be recycled to give fibers and fleece materials for clothing and carpets. Unsaturated polyesters are thermosets; they are used as the matrix material in glass fiber/polyester composites. Polyester elastomers are resilient and stretch up to 45% in length; they have good fatigue resistance and retain flexibility at low temperatures.

Composition (summary)

$(\text{CO}-(\text{C}_6\text{H}_4)-\text{CO}-\text{O}-(\text{CH}_2)_2-\text{O})_n$

General properties

Density	1.29e3	-	1.4e3	kg/m ³
Price	* 1.33	-	1.47	GBP/kg
Date first used	1941			

Mechanical properties

Young's modulus	2.76	-	4.14	GPa
Shear modulus	* 0.994	-	1.49	GPa
Bulk modulus	4.95	-	5.2	GPa
Poisson's ratio	* 0.381	-	0.396	
Yield strength (elastic limit)	56.5	-	62.3	MPa
Tensile strength	48.3	-	72.4	MPa
Compressive strength	62.2	-	68.5	MPa
Elongation	30	-	300	% strain
Hardness - Vickers	17	-	18.7	HV
Fatigue strength at 10 ⁷ cycles	* 19.3	-	29	MPa
Fracture toughness	4.5	-	5.5	MPa.m ^{0.5}
Mechanical loss coefficient (tan delta)	* 0.00966	-	0.0145	

Thermal properties

Melting point	212	-	265	°C
Glass temperature	67.9	-	79.9	°C
Maximum service temperature	66.9	-	86.9	°C
Minimum service temperature	* -123	-	-73.2	°C
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.138	-	0.151	W/m.°C
Specific heat capacity	* 1.42e3	-	1.47e3	J/kg.°C

Thermal expansion coefficient	115	-	119	µstrain/°C
Electrical properties				
Electrical conductor or insulator?	Good insulator			
Electrical resistivity	3.3e20	-	3e21	µohm.cm
Dielectric constant (relative permittivity)	3.5	-	3.7	
Dissipation factor (dielectric loss tangent)	* 0.003	-	0.007	
Dielectric strength (dielectric breakdown)	16.5	-	21.7	1000000 V/m
Optical properties				
Transparency	Transparent			
Refractive index	1.57	-	1.58	
Processability				
Castability	1	-	2	
Moldability	4	-	5	
Machinability	3	-	4	
Weldability	5			
Eco properties				
Embodied energy, primary production	* 80.9	-	89.5	MJ/kg
CO2 footprint, primary production	* 3.76	-	4.15	kg/kg
Recycle	True			
Recycle mark				



Supporting information

Design guidelines

There are four grades of thermoplastic polyesters: unmodified, flame retardant, glass-fiber reinforced and mineral-filled. Unmodified grades have high elongation; flame retardant grades are self-extinguishing; glass-fiber reinforced grades (like Rynite) are some of the toughest polymers but there are problems with dimensional stability; and mineral-filled grades are used to counter warping and shrinkage although some strength is lost. The PET used in carbonated drink containers is able to withstand pressure from within, it is recyclable and lighter than glass. The limits of the material's permeability to oxygen is overcome by sandwiching a layer of polyethylvinylidene-alcohol between two layers of PET giving a multi-layer material that can still be blow molded. Polyester can be optically transparent, clear, translucent, white or opaque; the resin is easily colored.

Technical notes

Polyesters are made by a condensation reaction of an alcohol like ethyl alcohol (the one in beer) and an organic acid like acetic acid (the one in vinegar). The two react, releasing water, and forming an ester. PET, PBT and PCT are not cross-linked and thus are thermoplastic. The polyesters that are used as the matrix polymer in bulk and sheet molding compounds are thermosets

Typical uses

Electrical fittings and connectors; blow molded bottles; packaging film; film; photographic and X-ray film; audio/visual tapes; industrial strapping; capacitor film; drawing office transparencies; fibers. Decorative film, metallized balloons, photography tape, videotape, carbonated drink containers, ovenproof cookware, windsurfing sails, credit cards.

Tradenames

Arnite, Eastabond, Eastapak, Ektar, Grilpet, Impet, Kodapak, Melinar, Petra, Plenco, Polyclear, Rynite, Selar, Techster, Valox

Links

Reference
ProcessUniverse
Producers

Values marked * are estimates.

Poly lactide (PLA)

Description

Image



Caption

Poly lactide food packaging. © Cargill Dow

The material

Poly lactide, PLA, is a biodegradable thermoplastic derived from natural lactic acid from corn, maize or milk. It resembles clear polystyrene, provides good aesthetics (gloss and clarity), but it is stiff and brittle and needs modification using plasticizers for most practical applications. It can be processed like most thermoplastics into fibers, films, thermoformed or injection molded.

General properties

Density	1.24e3		kg/m ³
Price	* 1.38	- 1.66	GBP/kg
Date first used	1993		

Mechanical properties

Young's modulus	3.3	- 3.6	GPa
Shear modulus	* 1.2	- 1.29	GPa
Bulk modulus	* 5.7	- 6.3	GPa
Poisson's ratio	* 0.38	- 0.4	
Yield strength (elastic limit)	55	- 72	MPa
Tensile strength	47	- 70	MPa
Compressive strength	66	- 86	MPa
Elongation	3	- 6	% strain
Hardness - Vickers	* 17	- 22	HV
Fatigue strength at 10 ⁷ cycles	* 22.2	- 27.7	MPa
Fracture toughness	* 3	- 5	MPa.m ^{0.5}
Mechanical loss coefficient (tan delta)	0.06	- 0.09	

Thermal properties

Melting point	145	- 177	°C
Glass temperature	52	- 60	°C
Maximum service temperature	* 45	- 55	°C
Minimum service temperature	-20	- -10	°C
Thermal conductor or insulator?	Good insulator		
Thermal conductivity	0.13	- 0.16	W/m.°C
Specific heat capacity	1.18e3	- 1.21e3	J/kg.°C
Thermal expansion coefficient	* 126	- 145	µstrain/°C

Electrical properties

Electrical conductor or insulator?	Good insulator		
Electrical resistivity	* 3e17	- 6e17	µohm.cm
Dielectric constant (relative permittivity)	* 3	- 3.5	
Dissipation factor (dielectric loss tangent)	* 0.001	- 0.02	
Dielectric strength (dielectric breakdown)	* 15	- 17	1000000 V/m

Optical properties

Transparency
Refractive index

Transparent
* 1.4 - 1.48

Processability

Moldability
Formability
Machinability
Weldability

4 - 5
* 4 - 5
* 4 - 5
* 3 - 4

Eco properties

Embodied energy, primary production
CO2 footprint, primary production
Recycle

* 49 - 54.2 MJ/kg
* 3.43 - 3.79 kg/kg
True

Recycle mark



Supporting information

Design guidelines

PLA is a biopolymer that can be molded, thermoformed and extruded, much like any other thermoplastic. It is transparent and has FDA approval for food packaging. PLA film and sheet can be printed and laminated. Biopolymers are, however, expensive, costing 2 to 6 times as much as commodity plastics like polypropylene.

Technical notes

PLA is a thermoplastic derived primarily from annually renewable resources (maize, corn or milk). It is available in a number of grades, designed for ease of processing. In-line drying may be needed to reduce water content for extrusion and molding. The recommended molding temperature is 165 - 170 C.

Typical uses

Food packaging, plastic bags, plant pots, diapers, bottles, cold drink cups, sheet and film.

Tradenames

NatureWorks PLA, BOPLA

Further reading

See Reference link and Producer website.

Links

Reference
ProcessUniverse
Producers

Values marked * are estimates.

No warranty is given for the accuracy of this data

Starch-based thermoplastics (TPS)

Description

Image



Caption

Mater-Bi polysaccharide fruit packaging trays. © Novamont SPA

The material

Starch is a naturally occurring polysaccharide made up of glucose molecules. Its molecular chains are shorter than those of cellulose and the bonds between the sugar molecule building blocks are different. Starch is therefore a polymer, but the problem with using it for making structural products is that it is softened by and dissolves in water.

Mater-Bi is a family of biodegradable thermoplastics materials made from maize starch. They are water resistant and resembles polymers made from petro-chemicals. They retain their properties while in use, but when composted in an environment containing bacteria, they biodegrade to carbon dioxide, water and fibrous residue.

Composition (summary)

Complex hydrocarbons.

General properties

Density	1.26e3	-	1.28e3	kg/m ³
Price	* 1.28	-	3.84	GBP/kg
Date first used	1990			

Mechanical properties

Young's modulus	0.24	-	1.5	GPa
Shear modulus	* 0.15	-	0.9	GPa
Bulk modulus	* 2	-	2.5	GPa
Poisson's ratio	* 0.4	-	0.44	
Yield strength (elastic limit)	16	-	22	MPa
Tensile strength	16	-	22	MPa
Compressive strength	* 20	-	28	MPa
Elongation	10	-	80	% strain
Hardness - Vickers	* 4.8	-	6.6	HV
Fatigue strength at 10 ⁷ cycles	* 5.6	-	7.7	MPa
Fracture toughness	* 0.8	-	1.3	MPa.m ^{0.5}
Mechanical loss coefficient (tan delta)	* 0.05	-	0.2	

Thermal properties

Melting point	136	-	180	°C
Glass temperature	* 10	-	20	°C
Maximum service temperature	* 60	-	80	°C
Minimum service temperature	* -60	-	-50	°C
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	* 0.13	-	0.23	W/m.°C
Specific heat capacity	* 1.5e3	-	1.7e3	J/kg.°C
Thermal expansion coefficient	* 180	-	240	µstrain/°C

Electrical properties

Electrical conductor or insulator?	Good insulator		
Electrical resistivity	* 1e16	- 1e18	μohm.cm
Dielectric constant (relative permittivity)	* 4	- 5	
Dissipation factor (dielectric loss tangent)	* 0.05	- 0.15	
Dielectric strength (dielectric breakdown)	* 12	- 16	1000000 V/m

Optical properties

Transparency	Transparent		
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Processability

Moldability	4	-	5
Machinability	4	-	5
Weldability	3	-	4

Eco properties

Embodied energy, primary production	* 23.9	-	26.5	MJ/kg
CO2 footprint, primary production	* 1.05	-	1.16	kg/kg
Recycle	True			

Recycle mark



Supporting information

Design guidelines

Mater-Bi can be used in most established plastics processing operations including the manufacture of films and foam, injection molding and thermoforming. Bottles and containers made from Mater-Bi are safe for many food applications, including oils or oily food, but over a long period of time the material is slightly permeable to water. It has been developed to have properties comparable to plastics such as polystyrene, polyethylene and polyurethane. The Mater-Bi range of polysaccharides can be extruded, injection molded, thermo-formed and foamed.

The materials achieve 90 per cent degradation in 50 - 120 days under normal aerobic composting conditions, decomposing to compost that is used for soil improvement for farming and growing. They have been accepted for certification as biodegraded compost under European Standard EN13432.

Technical notes

Mater-Bi is a biopolymer made from maize starch using additives to create macromolecules. The process uses the amylose component of the starch that is converted chemically to a less granular or crystalline form. This is then reacted chemically by a process called complexing with natural or synthetic complexing agents that promote bond formation between the starch molecule chains.

Typical uses

Injection molded: pencil sharpeners, rulers, cartridges, toys, plant pots, plastic bones and other toys for pets, plastic cutlery, hair combs.

Thermo-formed: trays for fresh food packaging, especially fruit and vegetables.

Film extrusion: shopping bags, bubble film for wrapping, plastic laminates for paper cups and plates, bags for rubbish disposal, lining for baby nappies, mulching films for horticulture, wrapping for fruit, vegetables and sanitary products.

Tradenames

TPS, Mater-Bi

Links

Reference
ProcessUniverse
Producers

Values marked * are estimates.

No warranty is given for the accuracy of this data

Polyamides (Nylons, PA)

Description

Image



Caption

1. Knot tied in a polyamide rope. © Brighterorange at en.wikipedia - (CC BY-SA 3.0) 2. Locking nut with polyamide insert to lock its screw in place. © Cav at en.wikipedia - Public domain 3. Students creating Nylon-6,6 in the laboratory at the University

The material

Back in 1945, the war in Europe just ended, the two most prized luxuries were cigarettes and nylons. Nylon (PA) can be drawn to fibers as fine as silk, and was widely used as a substitute for it. Today, newer fibers have eroded its dominance in garment design, but nylon-fiber ropes, and nylon as reinforcement for rubber (in car tires) and other polymers (PTFE, for roofs) remains important. It is used in product design for tough casings, frames and handles, and - reinforced with glass - as bearings gears and other load-bearing parts. There are many grades (Nylon 6, Nylon 66, Nylon 11....) each with slightly different properties.

Composition (summary)

$(\text{NH}(\text{CH}_2)_5\text{CO})_n$

General properties

Density	1.12e3	-	1.14e3	kg/m ³
Price	* 2.55	-	2.82	GBP/kg
Date first used	1938			

Mechanical properties

Young's modulus	2.62	-	3.2	GPa
Shear modulus	* 0.97	-	1.19	GPa
Bulk modulus	3.7	-	3.9	GPa
Poisson's ratio	0.34	-	0.36	
Yield strength (elastic limit)	50	-	94.8	MPa
Tensile strength	90	-	165	MPa
Compressive strength	55	-	104	MPa
Elongation	30	-	100	% strain
Hardness - Vickers	25.8	-	28.4	HV
Fatigue strength at 10 ⁷ cycles	* 36	-	66	MPa
Fracture toughness	* 2.22	-	5.62	MPa.m ^{0.5}
Mechanical loss coefficient (tan delta)	* 0.0125	-	0.0153	

Thermal properties

Melting point	210	-	220	°C
Glass temperature	43.9	-	55.9	°C
Maximum service temperature	110	-	140	°C
Minimum service temperature	* -123	-	-73.2	°C
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.233	-	0.253	W/m.°C
Specific heat capacity	* 1.6e3	-	1.66e3	J/kg.°C
Thermal expansion coefficient	144	-	149	µstrain/°C

Electrical properties

Electrical conductor or insulator?	Good insulator		
Electrical resistivity	* 1.5e19	- 1.4e20	μohm.cm
Dielectric constant (relative permittivity)	3.7	- 3.9	
Dissipation factor (dielectric loss tangent)	0.014	- 0.03	
Dielectric strength (dielectric breakdown)	15.1	- 16.4	1000000 V/m

Optical properties

Transparency	Translucent		
Refractive index	1.52	- 1.53	

Processability

Castability	1	- 2
Moldability	4	- 5
Machinability	3	- 4
Weldability	5	

Eco properties

Embodied energy, primary production	* 115	- 127	MJ/kg
CO2 footprint, primary production	* 7.58	- 8.38	kg/kg
Recycle	True		

Recycle mark



Other

Supporting information

Design guidelines

Nylons are tough, strong and have a low coefficient of friction, with useful properties over a wide range of temperature (-80 to +120 C). They are easy to injection mold, machine and finish, can be thermally or ultrasonically bonded, or joined with epoxy, phenol-formaldehyde or polyester adhesives. Certain grades of nylon can be electroplated allowing metallization, and most accept print well. A blend of PPO/Nylon is used in fenders, exterior body parts. Nylon fibers are strong, tough, elastic and glossy, easily spun into yarns or blended with other materials. Nylons absorb up to 4% water; to prevent dimensional changes, they must be conditioned before molding, allowing them to establishing equilibrium with normal atmospheric humidity. Nylons have poor resistance to strong acids, oxidizing agents and solvents, particularly in transparent grades.

Technical notes

The density, stiffness, strength, ductility and toughness of Nylons all lie near the average for unreinforced polymers. Their thermal conductivities and thermal expansion are a little lower than average. Reinforcement with mineral, glass powder or glass fiber increases the modulus, strength and density. Semi-crystalline nylon is distinguished by a numeric code for the material class indicating the number of carbon atoms between two nitrogen atoms in the molecular chain. The amorphous material is transparent; the semi-crystalline material is opal white.

Typical uses

Light duty gears, bushings, sprockets and bearings; electrical equipment housings, lenses, containers, tanks, tubing, furniture casters, plumbing connections, bicycle wheel covers, ketchup bottles, chairs, toothbrush bristles, handles, bearings, food packaging. Nylons are used as hot-melt adhesives for book bindings; as fibers - ropes, fishing line, carpeting, car upholstery and stockings; as aramid fibers - cables, ropes, protective clothing, air filtration bags and electrical insulation.

Tradenames

Adell, Akulon, Albis, Amilan, Ashlene, Capron, Celanese, Chemlon, Durethan, Gapex, Grilon, Grivory, Hylon, Kopa, Latamid, Lubrilon, Magnacomp, Maranyl, Minlon, NSC, Nivionplast, Novamid, Nydur, Nylamid, Nylene, Nypel, Orgamide, Radilon, Schulamid, Selar, Sniamid, Star-C, Star-L, Staramide, Texalon, Ultramid, Vestamid, Wellamid, Zytel

Links

Reference
ProcessUniverse
Producers

Values marked * are estimates.

Case Study

There was a study done in 2017 by Dr. Lois Krahn, published in Mayo Clinic magazine America which included 40 adults, all of whom slept with a dog either in their bed or elsewhere in their bedroom. Both humans and canines wore motion-tracking devices for seven nights, and humans answered questions about their quality of sleep and where their dogs spent the night.

The researchers found that having a dog in the bedroom did not necessarily compromise sleep quality, as had previously been suspected. On average, people with dogs in their rooms (but not on their beds) maintained 83% sleep efficiency—a comparison of time spent asleep to total time in bed. (80% is generally considered satisfactory.)

Sleeping with a dog in the bed, however, was linked to a slightly lower sleep efficiency: an average of around 80%. Though that is considered a satisfactory score, people with dogs in their beds woke up more throughout the night than those whose dogs slept elsewhere.

Human sleep companions, on the other hand, did not cause similar disturbances. Those who slept two-in-a-bed had better sleep efficiency than those who slept alone. “Presumably, humans accommodate the needs of their bed partner to promote sleep in a manner that even the most well-trained dog does not,” the authors wrote in their paper.

Lead author Dr. Lois Krahn, a sleep medicine specialist at the Centre for Sleep Medicine at the Mayo Clinic’s Arizona campus, says that for some owners, sleeping with an animal companion in the room can be comforting. “To have a purring cat or a well-behaved dog nearby may be very relaxing and conducive to sleep,” she said in a 2014 video interview after conducting a previous similar study. “Provided everyone sleeps well, it can be a benefit.”

But when people have multiple pets, it multiplies the chances for disruptions—like when dogs snore, move around or act out their dreams. That’s important, she says, because the number of people who have more than one pet has increased over the last decade. (In the current study, only single-dog households were included.)

The new study was small, did not contain a control group, and most of participants were healthy, middle-aged women—so the results may not apply to other populations. Because of the small size of the study, the researchers also couldn’t determine whether the breed or size of the dog made any difference. But the findings are still welcome news to anyone who loves snoozing with a pet but doesn’t want to sacrifice sleep.

“My main recommendation is for people to look at their setup and carefully consider whether it is truly working or not,” Krahn said, “and not allow loyalty to their pet to blind them to consequences that aren’t desirable to their sleep.”

And if you’re wondering how your pup feels about all this, don’t worry too much. “Regardless of location or an additional human bed partner,” the authors wrote in their paper, “dogs seemed to rest well during a preferred time, which has caused the owner to sleep at an irregular hour.”