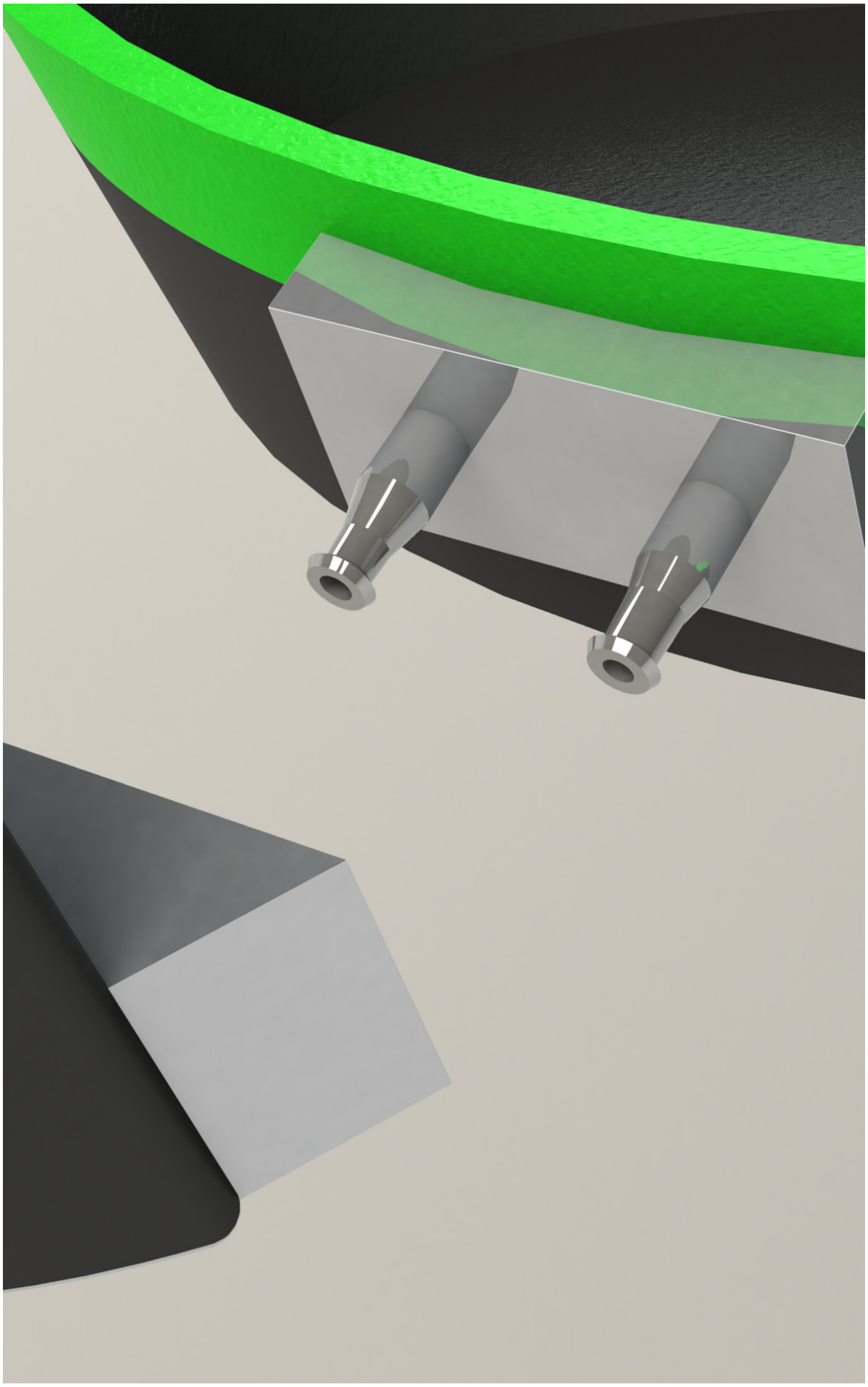

Citrus

Citrus

Paul Turnock
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CItrus is designing for students. Student kitchens are small and offer little storage space. Student kitchens also often lack a full complement of cookware and dishware. Students are active people. While not generally weak, sports and other activities can lead to aches and pains. The aims of the proposed product are to reduce the storage space needed in student kitchens, reduce the number of dishes needed to prepare and eat a meal and design a more ergonomic kitchen utensil.

Citrus has a very specific target market. Based on initial research, it has been concluded that most students have their kitchenware bought for them by their parents before moving to University. With this in mind, the goal of Citrus kitchenware is to appeal student's parents. Kitchen products that are high quality and functional are going to appeal to parents more than the lowest price approach that a student would look for, if buying on their own. Citrus serves the European Community and the student population in Europe is steadily climbing. Mass manufacturing will be required to keep up with the demand of this product and the design will keep in mind production quantities of no less than 100,000 units in the initial production run.

There are critical deadlines to be met with this project. While concept sketching and ideation will be constant throughout the project, the PPP's have a set deadline of 3PM on the 18th of March, 2010. This will allow for another week of final development and modelling before the 3D Model, PPP's, Design Document, Engineering GA and all previous developmental sketches and models are submitted on the 26th of March, 2010.

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product design specification

1. Performance

- This item acts like a normal pan on the hob but also acts like a plate on the table
- The handle on this pan is removable for eating and for storage
- Handle to come on and off 2,000 times
- Handles stay cool on the stovetop

2. Environment

- Oven Safe : 260° C
- Broiler Safe : No
- Refrigerator Safe : No
- Freezer Safe : No
- Dishwasher Safe : Yes
- Utensils : Nylon, Coated or Wooden
- Cleaning : Dishwasher proof
  : Dishwasher safe

3. Service Life

- 3 Year Limited Warranty
- Warranty covers manufacturing defects
- Lifespan of 1,000 uses
- Durable but not indestructable

4. Lifespan

- 3 Year Sales Lifespan
- 5 Year Service Lifespan
- Service parts no longer available after 5 years since last product sold

5. Manufacturing Cost

- Manufacturing Cost Not to Exceed £7
- Specific Manufacturer Not Yet Chosen

6. Market Price

- RRSP / MSRP Not to Exceed £30
- Debenhams and M&S Target Resellers

7. Manufacturing Volume

- Initial run of 100,000 units

8. Weight and Size

- With Handle Attached
  40cm Long x 22cm Wide x 17cm Tall
- Without Handle Attached
  22cm Long x 22cm Wide x 12cm Tall

9. Human Factors

- Optimised according to DTI studies
- Optimised according to NIOSH studies
- Handle reduces risk of strain to wrist
- Handle shortened reduces force required

10. Quality & Reliability

- MTBR is 3 Years
- MTBF is 4 Years

11. Standards and Specs

- Meets ISO 3055
- Meets ISO 9001
- Meets EN 2900

13. Packaging & Shipping

- 32cm x 32cm x 22cm Box
- Packed with handle detached
- Product shown on package

14. Maintenance Policy

- 2 Service Parts - Handle and Base
- Parts dispatched directly to user
- Non-functioning part returned by user

15. End of Life

- End of life recycling policy
- Dispatch prepair label to customer
- Customer boxes and returns to Citrus
- Materials Separated by Citrus
- Materials Given to 3rd Party Recyclers

brand introduction

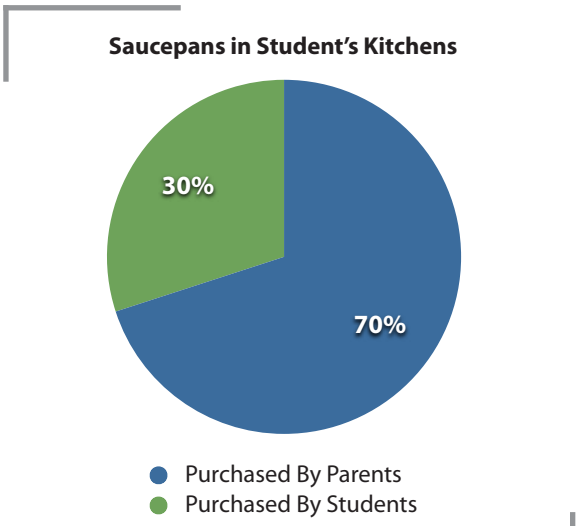
Citrus is vibrant, fresh and sharp. Citrus brightens up your kitchen. Citrus has new and exciting ideas. Citrus is simple and avoids unnecessary gimmicks. Citrus designs for students. More specifically, Citrus designs for student's mums in the European marketplace. Citrus believes that students are impossible to design for because their price range dictates the cheapest possible products. However, students usually receive their cookware from their parents when they move to university. Parents, unlike students, can have quality products marketed to them because they have more disposable income. The key to a successful Citrus saucepan is for a mum to see it on the shelf and say to herself "Jack would love this for his new kitchen!"

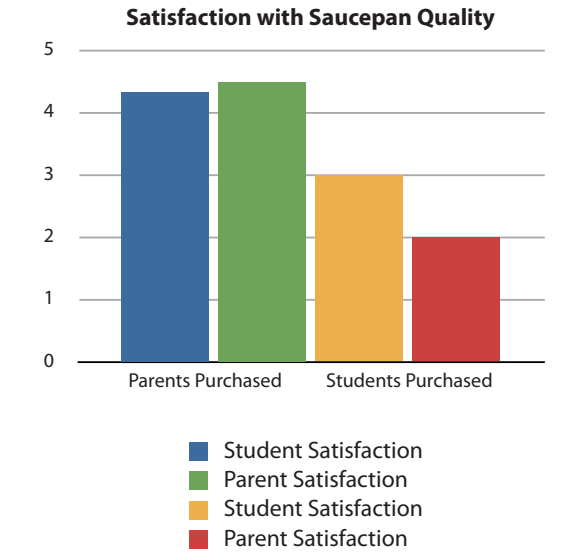
student's mums

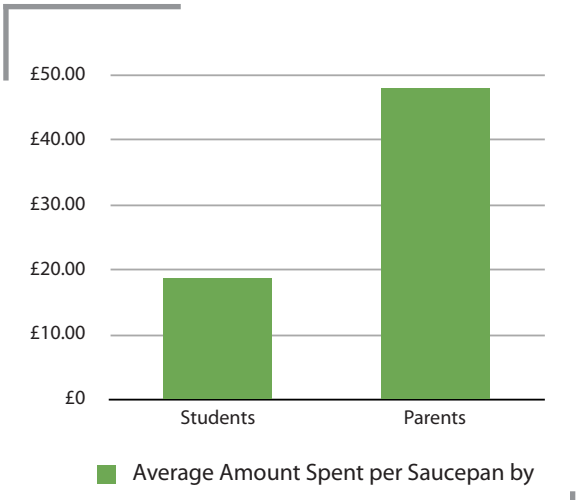
It is nearly impossible to design well made products for students. A student's budget will simply not allow for quality goods to be purchased. Students are usually looking for the absolute lowest price. What this means is that no one can design specifically for a student's needs. Instead, designers and manufacturers simply build the cheapest products possible knowing that students and others will be able to buy these goods simply because they cost less than every other product.

At Citrus, there has been a belief from the beginning that most students don't buy their own kitchenware. A quick poll around the design team and the lecture hall showed that most students had their kitchen products purchased for them by a parent. Unlike students, parents can have products designed for them. They have a little more spending cash and are looking for a higher quality item that will last longer and work better than the lowest cost items available at the local discount store. This is the target market for Citrus. To be sure that this target market exsts a small survey was put together

The graphs to the right show that not only did most students receive their saucepans from their parents but the parents were willing to spend more money per saucepan. On top of that the students and parents reported being happier with the quality of the products purchased when the parents did the purchasing. The next two pages show the survey that was put together. One survey is for parents, the other for students.







student kitchenware questionnaire

		Strongly Disagree				Strongly Agree
1.	*You brought all of your dishes to University from home.*	☐	☐	☐	☐	☐
2.	*You brought all of your utensils to University from home.*	☐	☐	☐	☐	☐
3.	*You brought all of your pots and pans to University from home.*	☐	☐	☐	☐	☐
4	*Your parents purchased all of your dishes for your kitchen at University*	☐	☐	☐	☐	☐
5	*Your parents purchased all of your utensils for your kitchen at University*	☐	☐	☐	☐	☐
6	*Your parents purchased all of your pots and pans for your kitchen at University*	☐	☐	☐	☐	☐
7	*You are satisfied with the number of dishes you have at University*	☐	☐	☐	☐	☐
8	*You are satisfied with the number of utensils you have at University*	☐	☐	☐	☐	☐
9	*You are satisfied with the number of pots and pan you have at University*	☐	☐	☐	☐	☐
10	*You are satisfied with the quality of dishes you have at University*	☐	☐	☐	☐	☐
11	*You are satisfied with the quality of utensils you have at University*	☐	☐	☐	☐	☐
12	*You are satisfied with the quality of pots and pan you have at University*	☐	☐	☐	☐	☐
13	*What price range did/would you consider if buying a new plate?*	Under £15	£16-£30	£31-£45	£46-£60	Above £61
14	*What price range did/would you consider if buying a new knife?*	Under £15	£16-£30	£31-£45	£46-£60	Above £61
15	*What price range did/would you consider if buying a new saucepan?*	Under £15	£16-£30	£31-£45	£46-£60	Above £61

parent kitchenware questionnaire

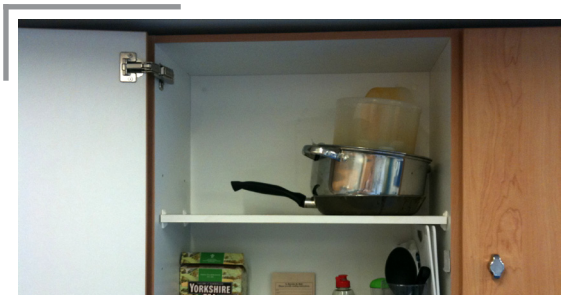
		Strongly Disagree				Strongly Agree
1.	*Your student brought all of your dishes to University from home.*	☐	☐	☐	☐	☐
2.	*Your student brought all of your utensils to University from home.*	☐	☐	☐	☐	☐
3.	*Your student brought all of your pots and pans to University from home.*	☐	☐	☐	☐	☐
4	*You purchased all of the dishes for your student's kitchen at University*	☐	☐	☐	☐	☐
5	*You purchased all of the utensils for your student's kitchen at University*	☐	☐	☐	☐	☐
6	*You purchased all of the pots and pans for your student's kitchen at University*	☐	☐	☐	☐	☐
7	*You are satisfied with the number of dishes your student has at University*	☐	☐	☐	☐	☐
8	*You are satisfied with the number of utensils your student has at University*	☐	☐	☐	☐	☐
9	*You are satisfied with the number of pots and pans your student has at University*	☐	☐	☐	☐	☐
10	*You are satisfied with the quality of dishes your student has at University*	☐	☐	☐	☐	☐
11	*You are satisfied with the quality of utensils your student has at University*	☐	☐	☐	☐	☐
12	*You are satisfied with the quality of pots and pans your student has at University*	☐	☐	☐	☐	☐
13	*What price range would you consider if buying a new plate for your student?*	Under £15	£16-£30	£31-£45	£46-£60	Above £61
14	*What price range would you consider if buying a new knife for your student?*	Under £15	£16-£30	£31-£45	£46-£60	Above £61
15	*What price range would you consider if buying a new saucepan for your student?*	Under £15	£16-£30	£31-£45	£46-£60	Above £61

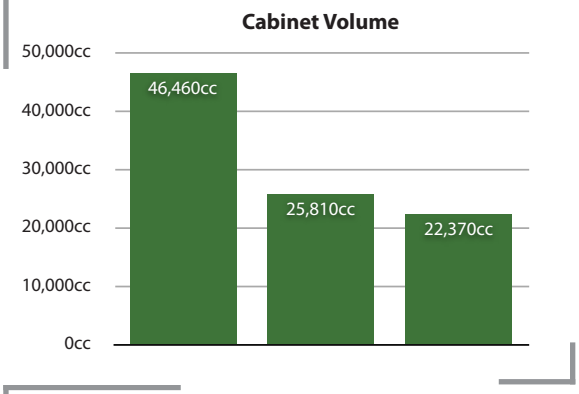
student's kitchen storage

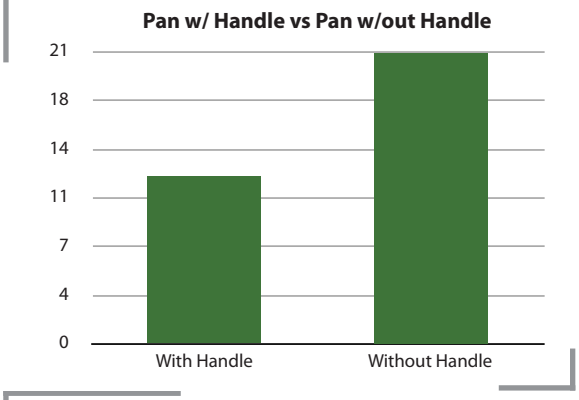
Students easily push any kitchen to its limits. Kitchens that were previously built for a three person family now hold dishes from four or five different students each with duplicate kitchenware. Even in on-campus accommodation there simply isn't room for every student to have a full complement of kitchenware. With this in mind Citrus aims to reduce the amount of space that a piece of cookware requires in the cupboard.

On a saucepan there is clear source of space waste, the handle. The handle protrudes from the saucepan which literally doubles the pan's volume if the the entire utensil is enclosed in a cube of space. One of the primary ways the Citrus saucepan will save space in a student kitchen is by having a removable handle. The handle will be designed so that it can easily be removed and replaced. On top of that the handle will fit into the saucepan when it is being stored. That way the handle will not get lost and will not take up extra space.

After measuring a student's cupboard and the space taken up by a saucepan with the handle attached, the space savings with the new design have been calculated at 1.7 times. This is not a perfect number because small items can fit around the handle of a normal saucepan. This calculation does not take that into account. The removable handle will really help a student use the small amount of space available in the cupboards. It will also allow for the potential sale of more Citrus brand kitchenware items as there will be room in the kitchen for them.







1.7x

as many pans with handle removed fit into the cupboard

Saucepans all have the same basic handles. The handle comes out the end of the pan and is nearly straight and nearly parallel to the work surface. It doesn't matter what the price range or purpose of the pan, its going to have a handle that is pretty much the same as every other pan.

The problem with these handles is that they are not particularly ergonomic. They aren't dangerous but they are not comfortable either. Students are young and may find ergonomics to be relatively unimportant. But students are also busy. Students are active. Students spend a lot of time typing. All of these activities can lead to small aches and pains in the wrists and sometimes worse. The photo below shows a standard pan being held. Notice the wrist is overextended. The chart below is cited from the *DTI Specific Anthropometric and Strength Data for People with Dexterity Disabilities* which was published in 2002. This chart shows that non-disabled people can more easily lift more weight with a vertical handle than a horizontal one.

3.5.2 Numbers (and percentages) of non-disabled participants according to the level of ease or difficulty experienced when lifting different weights on a platter equipped with a horizontal or a vertical handle

Weights - horizontal handle					
	0.25Kg	**0.5Kg**	**0.75Kg**	**1Kg**	**1.25Kg**
Cannot do	0 (0%)	0 (0%)	2 (2%)	10 (8%)	24 (19%)
Very difficult	0 (0%)	3 (2%)	10 (8%)	31 (25%)	49 (39%)
Can do	3 (2%)	16 (13%)	41 (33%)	50 (40%)	29 (23%)
Easy	25 (20%)	59 (47%)	55 (44%)	28 (22%)	21 (17%)
Very easy	98 (78%)	48 (38%)	18 (14%)	7 (6%)	3 (2%)
Weights - vertical handle					
	0.25Kg	**0.5Kg**	**0.75Kg**	**1Kg**	**1.25Kg**
Cannot do	0 (0%)	0 (0%)	1 (1%)	7 (6%)	21 (17%)
Very difficult	0 (0%)	2 (2%)	7 (6%)	27 (21%)	47 (37%)
Can do	3 (2%)	8 (6%)	43 (34%)	47 (37%)	30 (24%)
Easy	13 (10%)	44 (35%)	43 (34%)	32 (25%)	22 (17%)
Very easy	110 (87%)	72 (57%)	32 (25%)	13 (10%)	6 (5%)

handle exploration stage 1

The first concept for the handle is be based on a medical crutch. The image at the right shows the type of crutch that was the inspiration for stage 1 of the saucepan handle. This type of crutch spreads the forces involved with walking away from the wrist and to the arm. Because the arm is much stronger than the wrist or hand this really helps reduce the risk of injury to the wrist.

The saucepan handle designs use a similar principle. Three different sized handles can be seen to the right. They are all facing to the right. That is where the saucepan would connect. The vertical part is where the user holds the handle. Then the bottom bit that sticks out to the left goes underneath the hand to reduce the amount of force that needs to be exerted by the user.

The last two images are these weight spreading handles in action. These illustrations clearly show how the handles connect to the saucepan and how the user holds them.

After some testing, these handles were show not to be optimal. The vertical grab position is awkward to hold and the weight spreader does not go far enough back to reach the arm and spread any weight. If it did the handle would be far too large for normal use. Stage 2 of the handle development simplifies this concept and uses more sound ergonomic principles.

handle exploration stage 2

Stage 2 of the saucepan handle development involved the creation of a pistol grip style handle. This handle is sized at about 40mm to to be the most comfortable according to a DTI study that is cited in 2 pages time. 40mm is comfortable for both males and females in both the right and left hand.

The key design decision with this handle was to determine its distance from the saucepan and its orientation to the saucepan. Increasing the distance will increase the amount of force placed on the user's hand, assuming the weight of the pan and the food remains constant. However, making the distance between the pan and the handle shorter means that the user hand is closer to the hob. This increase the risk of the user burning him or herself on the hob or other cookware that is on the cooker. It will also increase the sensation and feeling of heat that is felt from the saucepan.

As is seen in the photos, it is possible to mount this handle in a more joystick-like position when compared to the handle of the pan. This would mathematically have a negligable effect on the perceived weight of the pan because the fulcrum point, application of force and the force caused by the weight of the pan have not moved. It does create an almost video game-like appeal to the pan. This would most likely alienate female users and is not in fitting with the Citrus brand of "Vibrant, Fresh and Sharp."

The third image from the top shows simply attaching this contoured handle to the end of a current "standard" pan handle will result in an overly long and awkward looking handle.

handle exploration stage 3

After informal testing of the handles on the previous page a compromise was made. It was clear that the concept of the handle extending underneath the user's wrist was simply not going to work. It would not change the fulcrum point, it would just spread the weight out to the wrist instead of the arm and was generally uncomfortable. The best solution came when grabbing the arched end of the handle and putting the part that went under the user's wrist underneath the pan. This led to a near vertical riser from the pan and a short, arched, handle for the user to grab onto.

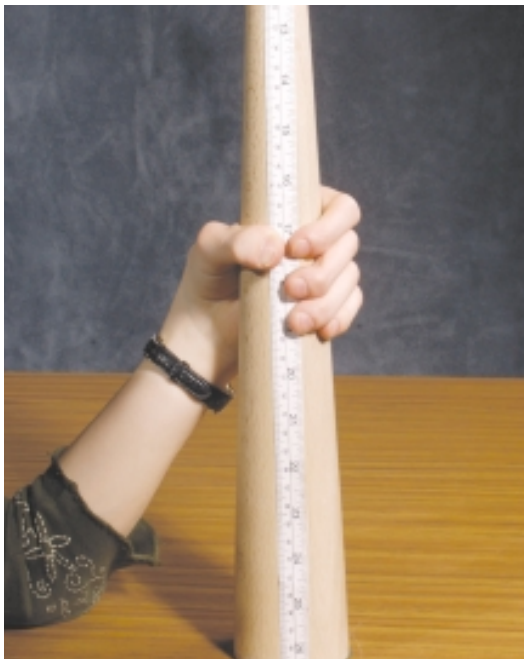
This handle keeps the user's wrist straight in line with the user's arm. This fixes the overextended wrist issue that the horizontal pan handles cause. It also gets the design closer to a vertical handle which was shown by DTI to allow for the user to more easily lift more weight. It also has a shorter handle in general which means the weight is closer to the fulcrum of movement and closer to the force applied by the user's wrist. The diameter of the handle is also 40mm at its biggest to support DTI's research (shown on the next page) about optimal handle diameter.

This handle should make the pan incredibly easy to lift and use for an extended period with optimal ergonomics for a human wrist.

The testing performed on the experimental handles is on the last three pages and is mostly practical with very little measurable data. Luckily, DTI has published excellent ergonomics information on handles.

This image and chart are from the *DTI Specific Anthropometric and Strength Data for People with Dexterity Disabilities* which was published in 2002. This chart shows the different preferred diameters for grasping something by non-disabled participants.

The chart clearly shows that there is a pretty common consensus. Both males and females in both their right and left hands prefer a handle around 40mm in diameter. Because of this the handle for this saucepan has been designed to have a diameter of about 40mm.



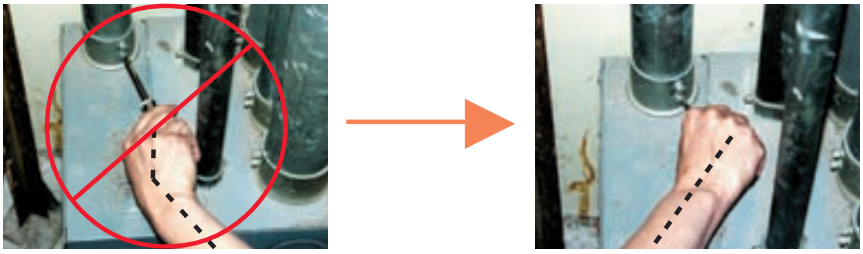
8.5.2 Non-disabled

Finger - thumb grasping diameters of non-disabled participants (mm)					
Male	**No.**	**Mean**	**S.D.**	**Min**	**Max**
Left hand	46	41.09	4.72	33.17	55.83
Right hand	46	41.16	3.34	31.97	54.23
Left and right combined	92	41.12	3.93	31.97	55.83
Female					
Left hand	78	39.97	3.91	30.22	51.82
Right hand	77	40.03	5.28	32.30	49.12
Left and right combined	155	40.00	4.48	30.22	51.82
Male and female combined					
Left hand	124	40.38	4.24	30.22	55.83
Right hand	123	40.46	4.19	31.97	54.23
Left and right combined	247	40.42	4.21	30.22	55.83

These images support the decision to have a curved handle. A normal horizontal handle on a pan causes the user to extend his wrist so that it is not parallel with his arm. These images are part of workplace health and safety guidelines from NIOSH and OSHA. The report is titled *A Guide to Selecting Non-Powered Hand Tools* and it was published in December of 2004.

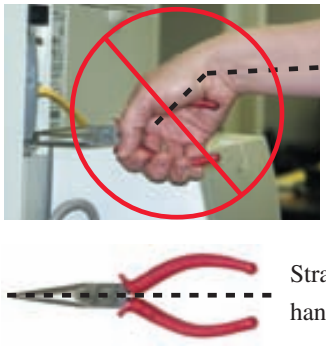
The bottom image asks the user to find a hand tool with a shape that will allow him to keep his wrist in an optimal, straight, position so that he can apply maximum force.

The top image is just a guideline about working in tight spaces. But again it encourages the user to choose a tool that will allow him to work with a straight, safe, wrist.

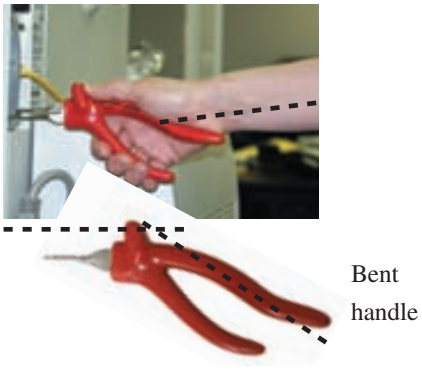


8 Select a tool with an angle that allows you to work with a straight wrist.

Tools with bent handles are better than those with straight handles when the force is applied horizontally (in the same direction as your straight forearm and wrist).



Straight handle

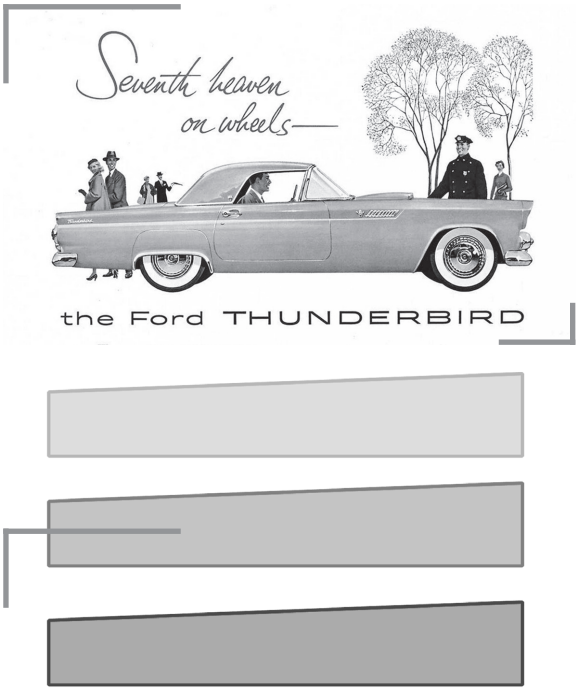


Bent handle

reverse wedge

The wedge is an interesting concept in automotive design. By making the front of the car shorter than the rear of the car it is made to look like it is about to pounce. However, I think that an even more impressive feat is the reverse wedge. By doing the opposite, the car looks like it is in the middle of pouncing on unsuspecting prey. It looks sharp and fast and in motion.

This Citrus branded saucepan needs to look fresh and sharp. By making the front lip of the pan slightly higher than the rear lip I can bring action to something as static as a saucepan.



mopar sublime

Auto manufacturers get a bad rap for meaningless and complicated vehicle colour names. Names such as “Lava Gray Pearl,” “Lake Silver Metallic” and “Ibis White” say nothing extra about the paint colours. However, MOPAR’s Dodge had the most descriptive colour name in its brochures.

Sublime is exactly what it says. It is the exact hue you think of when you think of something that is lime coloured. It is bright but somehow still relaxing. It catches the eye instantly but does not irritate it. Sublime is absolutely sublime.

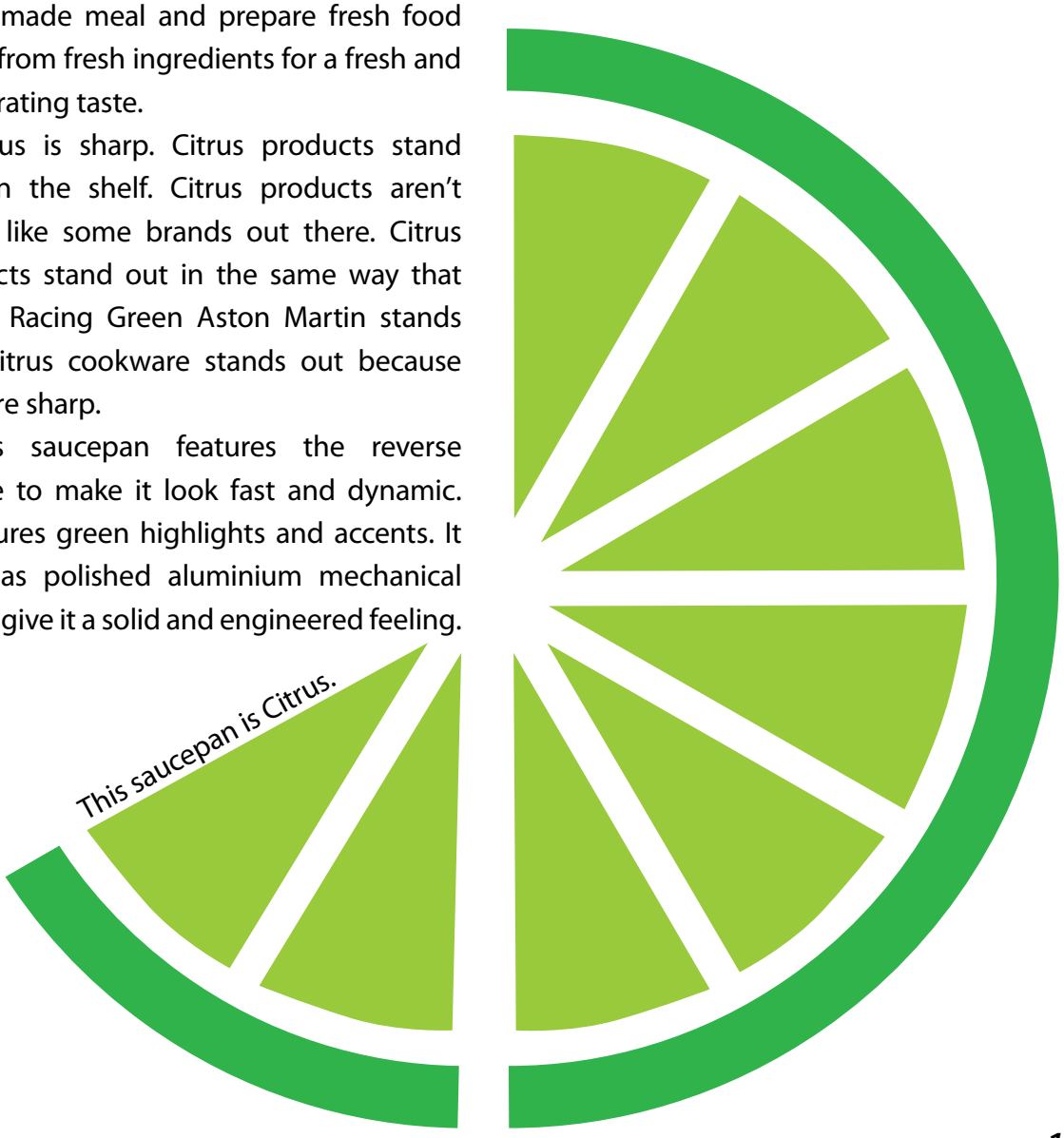
vibrant, fresh and sharp

Citrus is vibrant. Citrus makes refined products that have tasteful colour accents. Citrus is green. Citrus does not use its logo or its distinctive colour in vein. Highlights and gentle additions are how Citrus comes through on Citrus cookware.

Citrus is fresh. Citrus cookware prepares fresh food for the betterment of its young users. Citrus encourages its users to skip the ready made meal and prepare fresh food made from fresh ingredients for a fresh and invigorating taste.

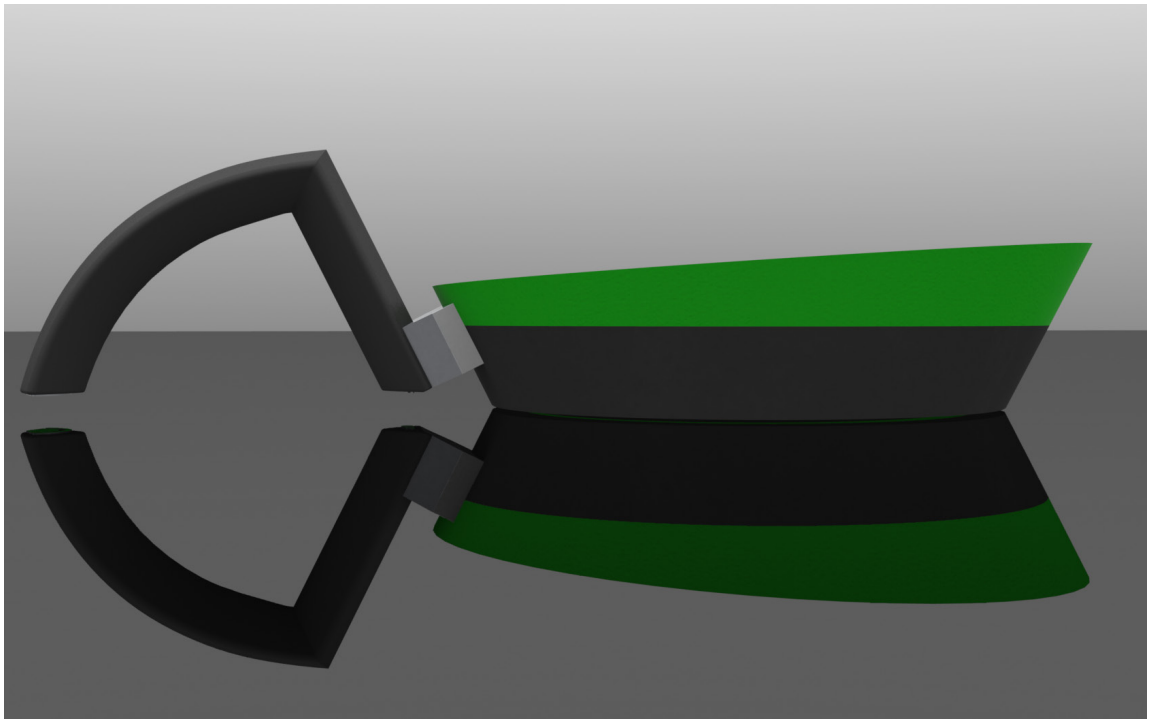
Citrus is sharp. Citrus products stand out on the shelf. Citrus products aren't goofy like some brands out there. Citrus products stand out in the same way that British Racing Green Aston Martin stands out. Citrus cookware stands out because they are sharp.

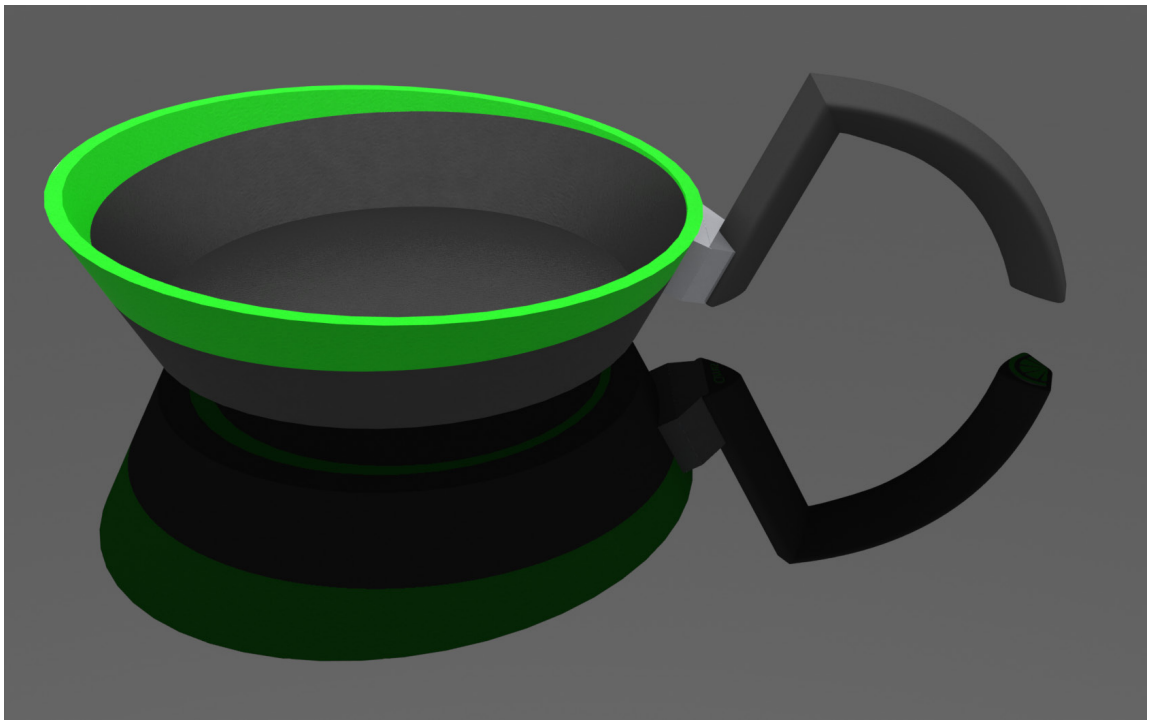
This saucepan features the reverse wedge to make it look fast and dynamic. It features green highlights and accents. It also has polished aluminium mechanical bits to give it a solid and engineered feeling.



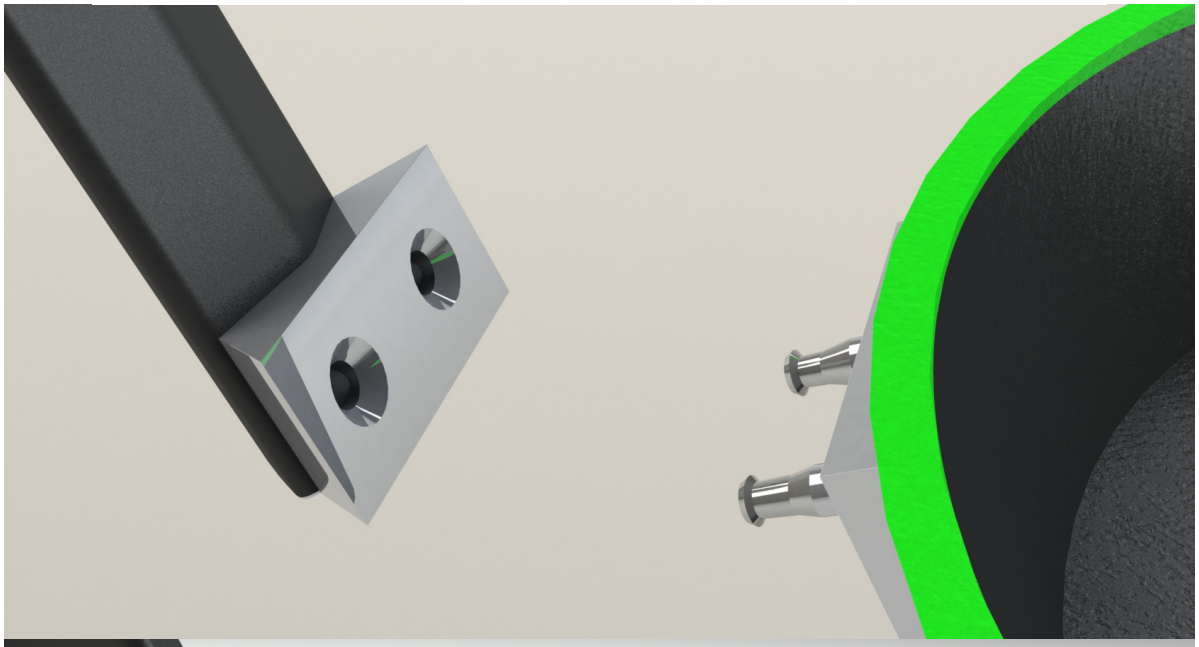
foam model

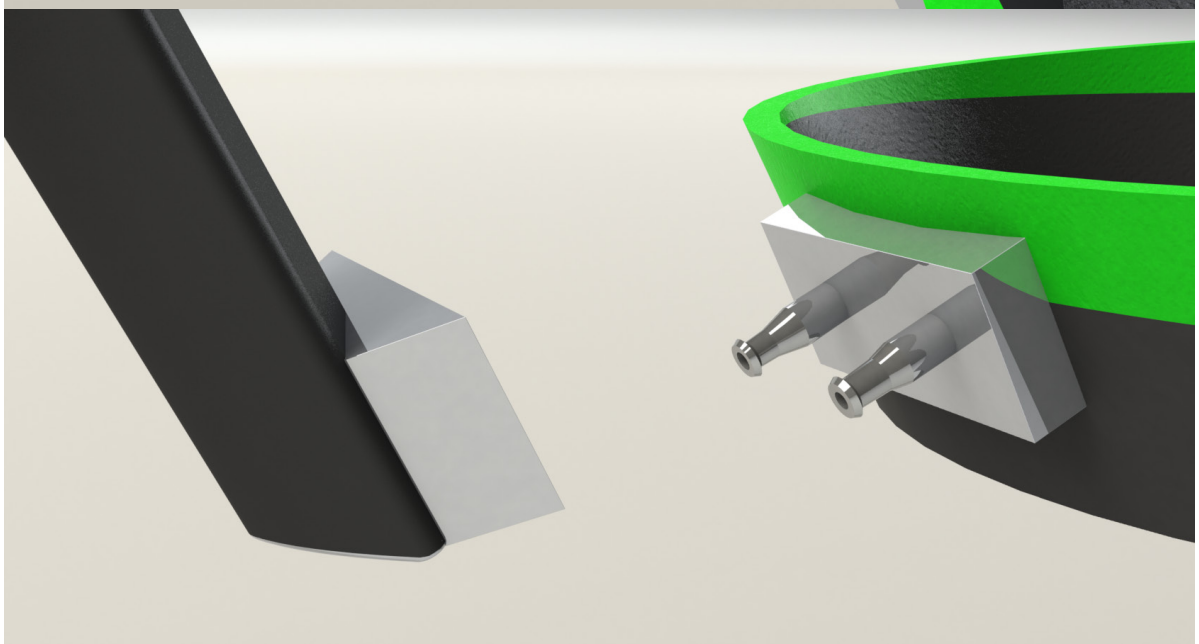
cad model






Citrus





proof of principle prototypes

There are several PPP's that make it simpler to understand the materials and attachments that go into this product.

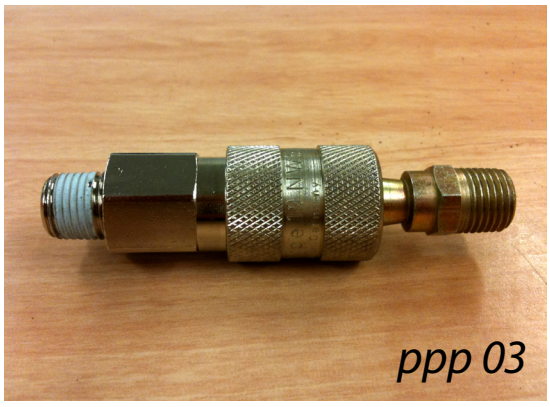
PPP01 is a pink knife. These come in many colours, including green. Unfortunately the green ones were sold out. But the point of this PPP is to show the type of coloured coating that the green stripe on the pan should be. The packaging for this product says that the the coloured coating is a non-stick coating. It must be a type of coloured PTFE coating.

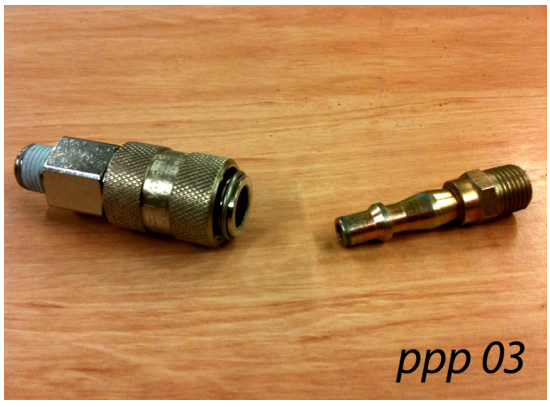
PPP02 is a green tin. The green colour is nearly perfect for the colour accents on this Citrus saucepan. However, the way the coating is applied is not acceptable. It is very poorly sprayed on and looks very low quality. Basically this saucepan should have the colour from PPP02 but the coating and finish of PPP01.

PPP03 is the key to the handle's functionality. The only cookware currently on the market that has removable handles are camping cookware. The handles and latches are of a very low quality. This pneumatic coupling valve is the perfect replacement. While this is an engineering piece and can require a lot of pressure to snap open and closed, the one that replaces it can be of a lower quality. The one that is on this saucepan needs the coupling action but does not need to hold air pressure and does not need to be so hard to open and close.


ppp 01

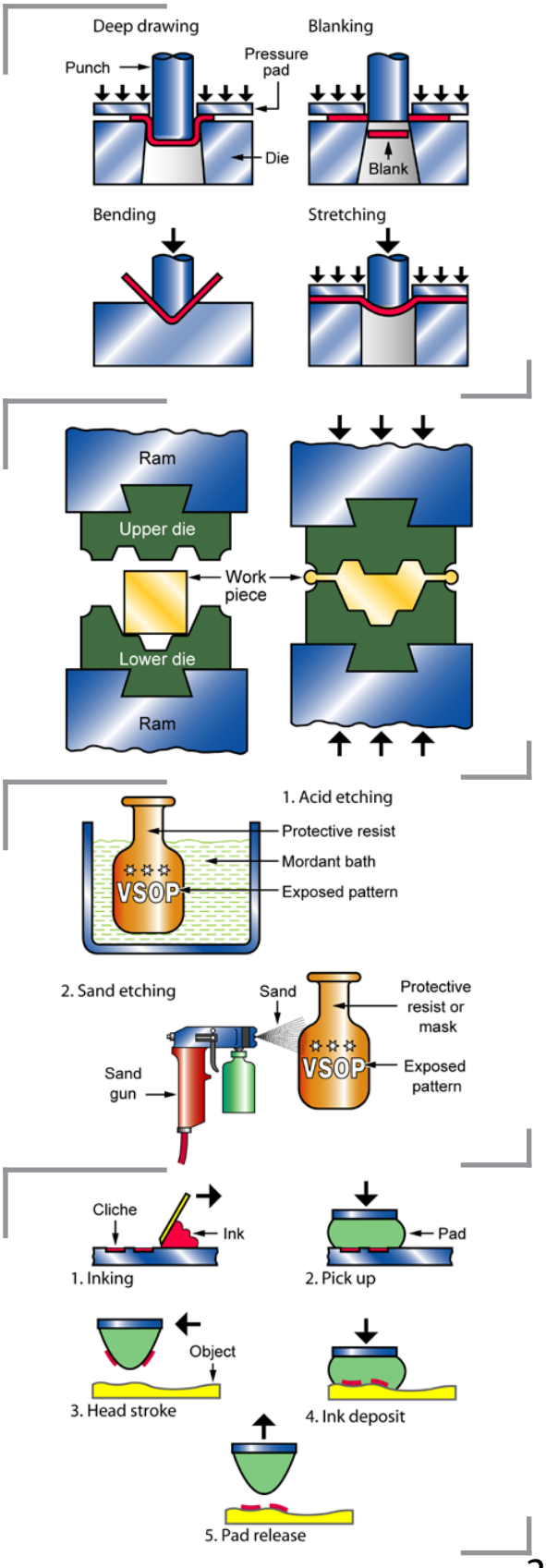

ppp 02

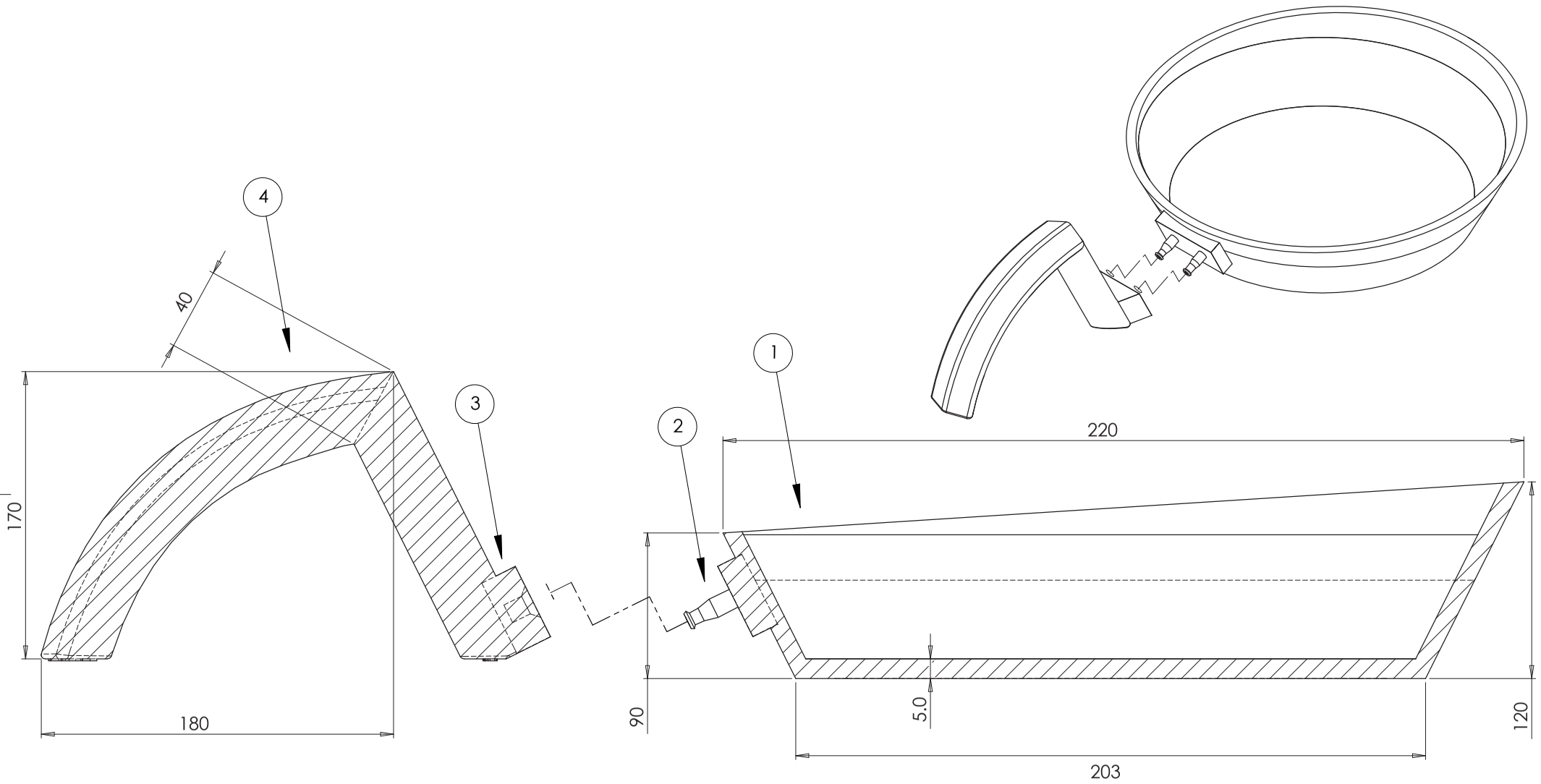

ppp 03


ppp 03

After reviewing the CES Materials and Processes database a construction process for production of at least 100,000 units has been developed. The process starts with a 5mm sheet of low carbon steel. It is deep drawn using a stamp tool. The excess steel is then removed to create the distinctive reverse wedge shape. The male end of the aluminium connection will be made by aluminium alloy die casting. Die casting allows for close tolerances and a great level of detail to be achieved. The female end of the aluminium connection will also be die cast. This part is larger because the aluminium reinforces the shape of the handle. The die for this bit will not allow for the holes to be cast economically so they will have to be drilled and chamfered in a secondary CNC manufacturing step. These parts will need to be polished after casting. Lastly the Styrene Acrylonitrile (SAN) handle will be polymer forged with the female aluminium cast as an insert. Polymer forging is a process that allows for thick walled plastics to be manufactured in economical, large, quantities.

Once the raw materials are formed, the finishes can be applied. The bottom of the pan will be painted with a standard dark grey heat resistant paint that is quite common on cookware. The inside will then be sand etched with PTFE and treated to form the non-stick surface. The green lip will be applied by dipped acid etching with green PTFE. The he green circle and Citrus logo on the bottom will be applied with pad printing.





	NAME	SIGNATURE	DATE
	Jeffrey Bergier		26.03.2010
CHK'D			
APPV'D			

PARTS LIST: NO.	PART NAME.	NO. OF PARTS per product	MATERIAL	MANUFACTURE
1	Pan Base	1	Mild Steel	Deep Drawn and Finished with PTFE Coating
2	Male Fastener	1	Aluminium Alloy	Die Cast and Polished
3	Female Fastener	1	Aluminium Alloy	Die Cast and Polished
4	Handle	1	SAN Polymer	Polymer Forged with Part 3 as Insert

TITLE: # Exploded Assembly

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

TOLERANCES:
ZERO PLACE DECIMAL 0.5mm
ONE PLACE DECIMAL 0.1mm

DWG NO. Drawing01

A3

SCALE:1:1

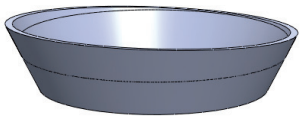
SHEET 1 OF 1

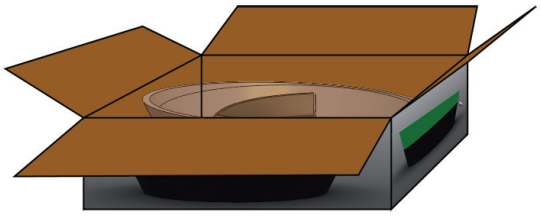
end of life

Citrus stands behind its products. This saucepan comes with a three year warranty against defects in manufacturing and/or workmanship. During that time Citrus will repair or replace any components that fail. This saucpan only has two serviceable components, the handle and the base. If the handle fails or the base fails a new one can be dispatched to the customer. On top of that, after the three years are up, the customer still has options. This saucepan has a service life of 5 years and can be serviced out of warranty until at least 5 years after the last sale of the last of this specific saucpan.

As far as disposing of the product once the customer no longer has a use for it, Citrus will help take care of that. As part of an environmental initiative, Citrus will dispatch a prepaid parcel label so that the customer can return the product for recycling. From there Citrus will separate the product into its component materials. Specifically that of steel components, aluminium components and thermoplastic components. While the specific plastic used is of Type 7 which is not recylable to the standard agencies, it is a thermoplastic. Citrus will partner with a a 3rd party recycler to help this material get the post-consumer treatment. Steel and aluminium are simple to recycle and Citrus will also partner with a specialised agency for the proper handling of those materials.

If any unexpected issue arise, Citrus will be prepared to deal with them and will remain responsive to customer concerns.





further development

In early Citrus history our pans had a colour changing logo at the centre of the top facing surface of the pan. This logo changed colour as the pan warmed up as a visual indicator of the pan's temperature. Researching the colour changing surface finish and application methods would prove a nice addition to the next iteration of this pan.

I started to design the shipping box, as can be seen on the previous page. It is very nice. It has actual size images of the pan on each surface from that angle. This is similar to how Apple does iMac boxes. However, creating the internal protection and packaging to hold the pan steady in the box is an area for future development. Also some development with palletising the boxes and shipping them across the ocean as economically as possible could increase margins on the sales of this product.

Right now I know how I would like the handle to attach with a mechanism similar to PPP03. However I don't know how to draw a connection like that in CAD and I don't know how to manufacture it. That being said, the current system will work even if there is no latch. The pan slides into the handle downward. Gravity alone holds the parts together as they are drawn now. But in the future that latch mechanism with a trigger underneath the handle will be the perfect solution.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DESIGN PROCESS 2 - DM2316
Academic Year 2009/10

MADE IN BRUNEL

DESIGN PROCESS
Academic Year 2009

olymers

The Thermoplastic Family

ABS
Tough, dimensionally stable, good surface finish.
Applications: The most commonly used moulding material for domestic electrical appliances. Telephone casings, golf balls, modern watches, camera casings and instrument panels.
Samples shown in the Lecture: Duracell Big Lamp, Duracell Torch, Fisher Price Magic Stars Toy, Dinosaur Light, CHANEL Compact case, LEGO bricks – LEGO Watch, BraunBlender – white body, red handle casing and Miele vacuum cleaner body casing.

POLYETHYLENE TEREPTHALATE - PETE
Low permeability to oxygen and carbon dioxide. Tough, rigid and transparent.
Applications: Blow moulded carbonated drinks bottles. Biaxially oriented film tape.
Samples shown in the Lecture: Bath Gel container, Mineral Water bottle, Food packaging trays.

POLYETHYLENE
Low Density Material - LDPE
Low processing costs, flammable, inert and flexible.
High Density Material - HDPE
Applications: Low density: Deep freeze packaging, bin liners, carrier bags. Boil-in-the-bag sachets. Detergent containers. Film for packaging.
High density: Wheelie bins, chemical drums, car fuel tanks, cosmetic bottles, extruded pipes, blow moulded toys.
Samples shown in the Lecture: Red blow moulded PE Watering Can (HDPE), Milk bottle and screw top (HDPE), Mr Muscle Sink & Plughole Unblocker bottle, Flash Bathroom Spray container + nozzle assembly components, Photographic Film canister and lid, Black Bin Liner (LDPE)
Air Cushion Packaging (LDPE) and plastic bags from the supermarket (LDPE).

PVC
A waxy, cheap and glossy material, poor UV resistance and easy to mould and form.
Applications: In plasticised, flexible form: clothing garments, dip coated handles, can caps, bicycle grips. Rigid unplasticised form: extruded UPVC window/door frames, curtain tracks, hoses, plastic 'wellies'.
Samples shown in the Lecture: Can Caps, Bicycle Handgrips, Artcare 'plastic' Sleeves.

VINYL CHLORIDE ACRYLATE - PVC/A
Application: Music records. 'Vinyl'.

POLYPROPYLENE
Tough, flexible, flammable. Floats. One of the cheapest materials with polystyrene.
Applications: One-piece plastic chairs, car bumpers, domestic buckets and bowls, cable clips, one-piece briefcases. The 'living hinge' 0.30mm-0.60mm web thickness.
Modified PP for thick handles (e.g. Kitchen tools & knives) with 10% talc filled blowing agent.
Samples shown in the Lecture: Large PP Swing Bin, Plant Pot, Kimberley Clark Gel Dispenser, Airwick Haze Air Freshener Can with PP cap, Sure Deodorant container, CD Stack container,

ACRYLONITRILE STYI
This is a specialised mate
Applications: Surfboards

TPE – Thermoplastic Ela
THERMOPLASTIC RUI
Applications: Styrene bu
Santoprene™ is DuPont
Neoprene™ is DuPont's
Applications: High tensil
Samples shown in the La
Original translucent tool

Kraton® D SBS copolym
The SBS block copolymer
Kraton® IR Latex is a TP

POLYURETHANE RUB
Applications: Vehicle ty
aircraft fuel tanks and ca
Samples shown in the La
and yellow) - glass fille
Stress Ball and Foam Pin

PCCR - footwear ("CRO

There are six generic cla
Styrenic block copolymer
Polyolefin blends
Elastomeric alloys (TPE-
Thermoplastic polyuretha
Thermoplastic copolyeste
Thermoplastic polyamide

Examples of TPE produc
(Shell chemicals), Pellet
While there are now man
TPE Group)), Santoprene
(So.F.Ter. S.p.a.); Alcryn

In order to qualify as a th
characteristics;
1. The ability to be stre
something close to its ori
2. Processable as a ma
3. Absence of significa

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Food (fruit cocktail) container, lid and integral spork), Protomold PP Cube, Clipfresh food container (Made in Taiwan) with four flap seal lid, Sushi food tray and lid (both parts PP)
Microwavable Takeaway Tray, Food container with peel seal lid, Paint Roller Tray, Electric Kettle Lid, Polish Cap featuring living hinge trigger flap, Prestige Kitchen Tool (orange & white), Prestige Kitchen Tool (wood effect), Egg Boiler, DVD Case with integral living hinge, Dulux Paint Sample container, Tesco Dustpan (a cheaper quality PP derivative called PAP 21).

LOW IMPACT POLYSTYRENE - GP
General Purpose Polystyrene.
Called 'styrene'. Brittle, hard, glossy surface, very easily moulded. Cheap.
Applications: Airfix kits, gift boxes, 'Ferrero Rocher' boxes. 'Tinny' sounding plastic.

HIGH IMPACT POLYSTYRENE - HIPS
More ductile than general purpose polystyrene.
Applications: Fridge interior liners, video cassette cases, rear mouldings of television casings, higher quality audio cassette cases and CD and DVD cases.
Samples shown in the Lecture: Airfix Kit, CD/DVD cases, CD Packaging Tray, Toy Puzzle – tiny geometric box, Ferrero Rocher Box, BIC Pen & lid (+ breathing hole), Müller Corner container.

ACRYLIC
Polymethylmethacrylate. A UV stable and optically clear plastic.
Common trade names: 'Plexiglass' and 'Perspex'.
Applications: Aircraft windows, guards & safety covers, lenses and decorative plastic products, cruets, baths, basins, rear light clusters of cars, applications where optical quality is paramount.
Samples shown in the Lecture: CPI Block, Salt Cruet.

STYRENE ACRYLONITRITE - SAN
A Polystyrene type polymer with stronger properties and less brittle. Tends to yellow with age.
Applications: Audio Deck Turntable covers, reflectors, CD/DVD cases, thermos flask casings.
Samples shown in the Lecture: Moulded container for weighing scale (sample used in drawing).

POLYCARBONATE
Non-flammable and mouldable in transparent. Sterilizable and very high impact strength.
Applications: Vandal-resistant light covers, baby's feeding bottles, hair drier casings, mouldings for coffee makers, high quality electronic product mouldings (ZENOY). Steam iron bodies. The most used material for the casings of mobile telephones. Strong and as thin as 1.1mm wall section. Modern mobile phones are manufactured in a cost effective copolymer, ABS/PC.
Samples shown in the Lecture: CD/DVD discs, Mobile Phone bodies (hybrid PC/ABS), Dyson DC01 Cleaning Head assembly.

POLYAMIDES - ALIPHATICS
NYLON 6, 66, 610 Good heat properties with low distortion and abrasion resistance.
Good general mechanical properties.
Applications: Textile industry products. As a monofilament: nylon stockings and tights, shirts and blouses. Applications: Nylon 6 and 66: zip fasteners, gears, filler caps.

ETHER VINYL ACETA
Tough rubber-like materi
Applications: Shoe soles,
Samples shown in the La

POLYPHENYLENE OXI
Self-extinguishing, does
Applications: Hot water
dashboard panels (PPO+
A low grade polysulphon
Sample shown in the Lec

POLYPHENYLENE SUI
Fire resistant, cheaper th
Applications: Domestic i
Samples shown in the La

Polyurethane - PU
HARD FOAMS Upon a
Applications: R.I.M. - re
Car bumpers, television

SOFT FOAMS Applica
Samples shown in the La

POLYURETHANE THE
Applications: Electrical a
This is an emerging mate
Samples shown in the La
modelmaking, in CNC
'tooling grade' and is n
material. The soft light
mouldings. The modelma

CLOSED CELL FOAMS
Plastazote ®, Evazote ®,
PCCR - Proprietary Clos

EPDM - Ethylene Prop
manufacturer of these m
Samples shown in the La

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DESIGN PROCESS
Academic Year 2009

NYLON 11, 12 More expensive, absorb less moisture, more flexible better dimensional stability.
Applications: Petrol hoses, hydraulic pipes, film for cooked meat packaging. (Better than cellulose Acetate... but more expensive).

MODIFIED ALIPHATICS The base material is modified to specifically add an engineering characteristic. Talcum powder is used to 'blow' thicker sections: cooker control knobs. Glass fibres or glass beads are added to strengthen the moulding: electric drill cases generally use 30% glass filled nylon 66.
Samples shown in the Lecture: 30% Glass strand-filled Nylon 66 Hydraulics Filler Cap for JCB, 30% Glass-bead-bead filled Nylon 66 Bosch Electric Drill body casing.

NOMEX Amorphous nylon aramid. Very high specification material.
Applications: Spacecraft re-entry parachutes: very light and extremely strong.

KEVLAR Amorphous nylon aramid. Applications: Ropes and ballistic vests.

ACETAL – Polyacetal
Also known as Polyformaldehyde. Homopolymer is tough and stiff as engineering grades, copolymer is non-toxic and has a high range of working temperatures. It is a high tolerance material – often used as a superior Nylon 66 alternative.
Applications: Jug kettle bodies (copolymer) Gearwheels,(copolymer) zip fasteners, counter wheels on petrol pumps, drives, integral spring switches on direction indicators.
Samples shown in the Lecture: Flat Hose Reel - carrier and hose – PP monocoque shell, ABS, PA.

ACETAL POLYOXYMETHYLENE Copolymer - POM
Excellent rigidity, impact toughness, abrasion resistance, creep resistance and solvent resistance. Good appearance, hydrolytic stability. Low coefficient of friction. DuPont's POM is Delrin™
Applications: Bearings, gears, electric kettles and water jugs, components with snap fits. Bathroom scales, telephone keypads, pulley wheels, and housings for domestic appliances, showerheads and toys.

CELLULOSE ACETATE
High gloss, high gas permeability, difficult to process.
Applications: Overhead projection film, protective film on food products.
Samples shown in the Lecture: Photographic film, OHP film sheets.

CELLULOSE ACETATE PROPIONATE - CAP
High gloss, transparent, hard, good impact, a more expensive material.
Applications: Blister packaging for consumer durable products, spectacle frames, toothbrush handles and the transparent dials on older telephones.

CELLULOSE ACETATE BUTYRATE - CAB
Tough, dimensionally stable. Applications: Screwdriver handles.
Samples shown in the Lecture: Translucent yellow and co-moulded screwdriver handles.

Specialised polymers nu
POLYIMIDES
Better impact than pheno
Applications: The 'Aron
motor insulation, wire co
Samples shown in the La

PBT
Dimensionally stable in
specifications. Applicatio
wipers, grilles, terminal
Samples shown in the La

POLYSULPHONE - PSU
High temperature applic
Applications: Microwave

POLYETHERESTER
Rubber like qualities, flex

POLYETHERSULPHON
Expensive. High tempera
high specification special
Applications: High spee
indicator lights in cooker

1 PETE 2 HDPE 3 V 4 LDPE 5 PF 6 PS 7 OTHER