



ENGINEERING DESIGN

Drill Press Redesign Report



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Introduction

On 17th November 2017 Richard Morgan handed out the assignment to redesign a drill press to be manufactured in a polymer and to be produced at 500 units per week. This assignment will analyse the original design and decide on critical design features that will need to remain in the design. It will then be modified to make it more suitable for manufacturing in a polymer. Research will also be undertaken to find a suitable material to use for the product.

Findings

Drill Press Features

The drill press is required to hold a drill in place facing down so that it can be lowered accurately via a lever and return up via a spring. The drill press requires the following;

- Hole for sliding onto main shaft
- Hole to attach drill
- Means of attaching lever
- Means of attaching return spring

These are critical design features that need to be kept in the design if modifications are made.

Manufacturing Method and Material Choice

As this part was to be made from a polymer, injection moulding seemed like the obvious choice with regards to manufacturing the part. However, selecting a material can be a difficult process as it is required to be strong enough for its purpose. For this reason research was carried out to compare several potential materials, findings can be found in the table below (Nicolet Plastics, 2017)

Based on the information below I will be giving a score to each rating based on these values;

Unknown – 0

Poor – 1

Low – 2

Fair – 3

Medium – 4

Good – 5

High – 6

Excellent – 7

Cost will also be included in the material selection process but will be doubly weighted in its scoring as it is one of the most important factors and will be scored as follows.

Low – 6

Medium – 4

High – 2

Material	Strength	Impact Resistance	Warp & Dimensional Accuracy	Fills Small Features	Voids in Thick Sections	Sinks in Thick Sections	Flash	Cost	Total Score
Acetal	Medium	Medium	Fair	Fair	Poor	Good	Good	Medium	29
Nylon 6/6	Medium	High	Fair	Excellent	Good	Fair	Poor	Medium	33
Nylon 6/6 Glass Filled	High	Medium	Fair	Good	Excellent	Good	Fair	Medium	37
Polypropylene	Low	High	Fair	Excellent	Poor	Poor	Poor	Low	27
High Density Polyethylene	Low	High	Fair	Excellent	Unknown	Poor	Poor	Low	26
Polycarbonate	Medium	High	Good	Fair	Fair	Fair	Good	High	31
ABS	Medium	High	Good	Fair	Good	Fair	Good	Low	37
Polystyrene	Medium	Low	Good	Good	Unknown	Fair	Fair	Low	28
Acrylic	Medium	Low	Good	Fair	Excellent	Good	Good	Medium	35

From the scores established in the table, the three best materials are ABS, Acrylic and Nylon 6/6 Glass Filled. Due to ABS being the lowest cost of the three this would be the material used to make the parts. It scored medium on strength and high on impact resistance so will be sufficient for the product being made. The extra cost of using Acrylic or Nylon 6/6 is not worth it for a product of this type. They do not outperform ABS enough to pay the extra for them.

Modifications

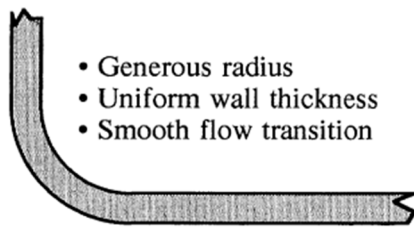
As the part was to be injection moulded then modifications would need to be made to improve the manufacturing process, and preventing any defects.

(Groover, 2010) Lists the common defects in injection moulded parts as;

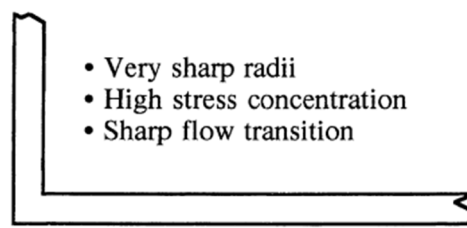
- **Short shots** – This is where the moulding has cooled and become solid before completely filling the cavity.
- **Flashing** – Flashing is where the polymer melt has seeped through the cracks between the moulding plates or ejection pins. This can occur when vents in the mould are too large, where injection pressure or temperature are too high or when the shot is too large.
- **Sinks and Voids** – Sinks occur when the outer part of the moulding cools and turns solid and the inner material cools more slowly, this contracts and pulls in the outer layer causing a sink. A void is similar but the outer layer stays where it is but the contraction internally causes an internal hole.
- **Weld Lines** - Weld lines occur when the polymer melt splits and then meets again in opposite directions. This joining will form a visible line that may be mechanically weaker than other parts of the moulding. This can be lessened by increasing temperature or pressure, or in extreme cases by altering the mould.

According to (Malloy, 2010) corners in the part should be given generous radii wherever possible. For this reason any flat surfaces will try to be designed out of the part.

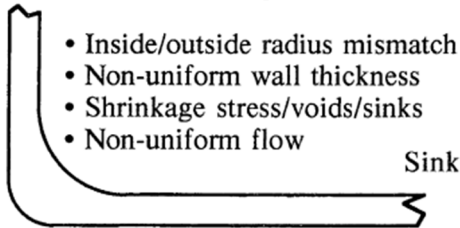
Good corner design



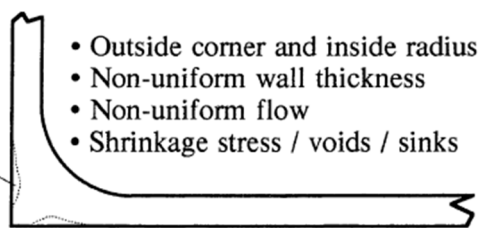
Incorrect corner design



Incorrect corner design



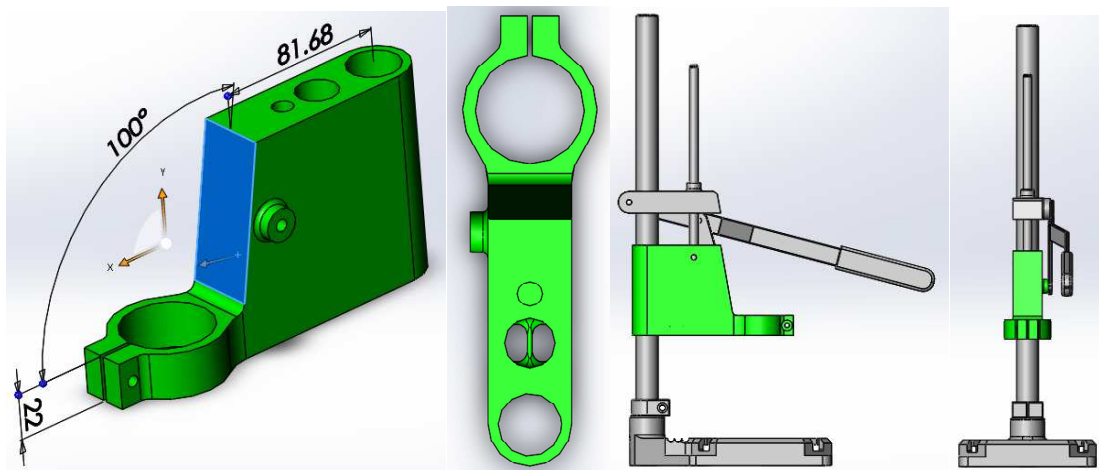
Incorrect corner design



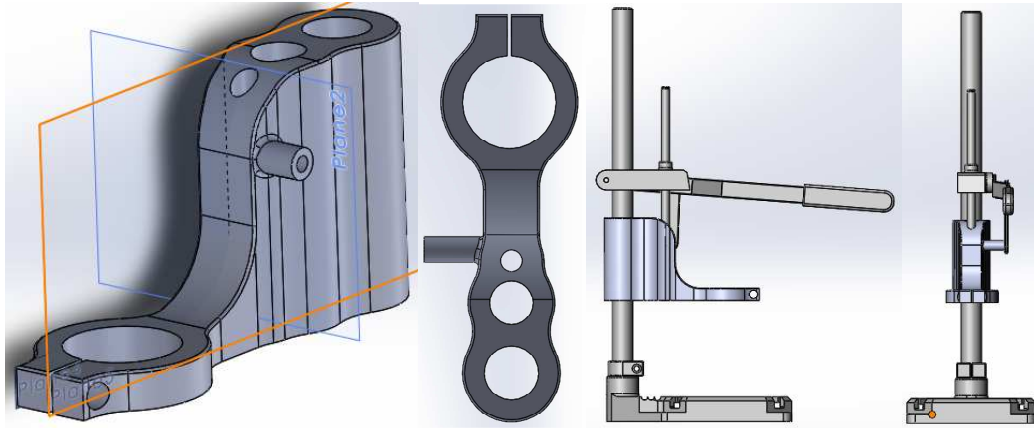
Sink

(Malloy, 2010)

Well-designed corners such as this allow the polymer melt to flow into the cavity well and it is less likely to miss the corner or cause a sink or void during the cooling stage.



The above images show the original drill press design. To improve the manufacturing of this product and to make the parts cheaper, the decision was taken to modify the part. The aim was to use less material, making the design more streamlined. This would benefit the customer in terms of costs and the environment. Modifications would also have to be made to make the part more suited to polymer manufacturing.



The modifications made can be seen in the images above. Measurements were taken of all the features and holes on the original part, these were then sketched out within the CAD package and the part was modelled from scratch around these features. You can see that the new part incorporates a lot more curved surfaces, this helps to avoid warpage when cooling the part and makes it easier to remove the part from the mould. The part retains all the necessary features to function as intended. The part was also made flat on the bottom edge as this would enable one side of the mould to be a flat plate meaning less money needing to be spent of creating the tooling for the mould.

Originally the design was going to include a cut-out in the centre of the part to cut down on material use. However it was decided that this would complicate the mould design far more than necessary and it would be more efficient to keep the part more simple.

Due to having limited experience with CAD software the product turned out better than expected although there is a lot of room for further improvement for someone more skilled with CAD software to carry out. After the first production run this design could be improved further if the customer is happy for this to happen.

Prototyping

To prototype the product a 3D printer could be used. (Stratasys, 2018) says that rapid prototyping gives you great flexibility to produce and test parts before committing to the very expensive tooling required to mass produce the product. Time is also a factor, rapid prototyping via 3D printing also saves 8 to 12 weeks that is required for creating tools.

"3D printing is another rapid prototyping process that allows for the production of 3D prototypes with good speed and accuracy" (Malloy, 2010)

This process works by loading a 3D model into a 'slicing' software. This cuts the model into layers that a printer can read. The printer will then read these files and lay down material layer by layer to form the 3D part. Material is fed via filament on a spool through a hot nozzle, melting the polymer to liquid form and delivering it to a build plate.

The downside of 3D printing is that the final part will not be as strong as an injection moulded part as each layer is not completely bonded together as it is with an injection moulded part.

“3D printing has a lot to offer the manufacturing process, but it isn’t likely to take over traditional methods. It’s more likely that 3D printers will work in conjunction with traditional methods by producing prototypes and creating injection molds. As 3D printers exist today, they won’t replace traditional subtractive machining or injection molding anytime soon.” (E&T Fasteners, n.d.)

Recycling Potential

During the research for this project a study was found that looked into recycling ABS in injection moulding machines (García, et al., 2016). This study focused on discovering what affect recycled material would have on the mechanical properties of a finished product. If the recycled material would lead to a weaker or more brittle product etc.

In this study 300 simple ABS parts were made, a selection were taken for testing and the rest reprocessed to be reused as new parts. This was repeated until there were four parts, the original parts and ones that had been processed once, twice or three times.

The results from the study can be seen below;

	Average of Strength and Tension				
	ABS	ABS-R	ABS-RR	ABS-RRR	
Strength (kN)	1.290	1.437	1.442	1.304	ABS – Original ABS-R – Recycled once ABS-RR – Recycled twice ABS-RRR – Recycled three times
Tension (N/mm ²)	32.258	35.758	36.540	32.622	

From these results it can be observed that the strength of the part actually improved when using recycled material once, and then again slightly on the second recycle. On the third the strength appears to return to its original figures.

The experiment concluded with the following;

“The mechanical recycling of ABS through melt processing in injection moulding was a simple method that did not affect the processing characteristics of the material up to three repeated extrusion cycles. Overall, it appears that recycling of ABS one or twice will generally improve mechanical properties that are lost due to degradation during recycling, with the exception of impact properties. However, the loss of impact strength may be improved by the addition of a suitable impact modifier.” (García, et al., 2016)

This study shows that recycled material can indeed be used when producing ABS products and this method should certainly be considered for the drill press part being made. Broken parts can potentially be reprocessed to be used for new parts. This will benefit the environment due to not requiring new material and any savings can also be passed on to the customer. In the future an arrangement could be discussed with the customer to perhaps return damaged parts for reprocessing, this could give the customer a discount off their future orders.

Cost

By loading up my drill press design in Cura (Free 3D printing software) it was calculated that each part would take 289g of ABS material to produce. This information was used to estimate that 3 parts could be produced for every kg of material.

From researching prices for ABS pellet material for injection moulding, two suppliers were found.

(Push Plastic, 2018) charge £11.06 per kg

(Omnidynamics, 2018) charge £11.99 per kg

Taking the average of £11.53 per kg, this means each part would cost approximately £3.84 in material. Discounts could likely be secured if material was bought in bulk as producing 500 units per week will need 167kg of material each week. Although multiple weeks or months worth could be purchased at a time.

Conclusion

This report has found that the drill press can successfully be made from a polymer and still function as intended, however modification of the original design was required to make the manufacturing simpler. ABS was chosen as a material as it offers good strength and impact resistance while remaining good value for money.

The part would first be prototyped using 3D printing and tested/modified as necessary. Once happy with the part, tooling would be made for an injection moulding machine. When completed, full production of 500 units per week can begin via injection moulding.

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