3D PRINTED PLASTIC PARTS

Introduction

Early in 2014, I began to experiment with 3D printed parts in the scratch construction of a 1:8 scale model of a 1935 Austin Seven Ruby. Once I was over the hurdle of learning CAD and creating STL files (the most common form of input file for 3D printers), I needed to find a source for the parts. Purchasing a 3D printer seemed premature since I had little familiarity with the various materials, their material properties and their finish qualities. Instead I turned to Shapeways (www.shapeways.com) whose website provided a convenient method to upload files, get prices for various materials and place orders. I have now ordered some 200 parts from Shapeways in a variety of materials.

Materials

The two basic plastic materials available for hobbyists are sintered nylon and acrylic.
Shapeways does offer a variety of other materials, including brass but they are relatively expensive. Nevertheless, I did 3D print the front axle in brass since the cross-section was little more than 1/8th of an inch square. With such a small cross-section neither nylon nor acrylic were strong enough to support the weight of the model without significant bending.

Nylon vs. Acrylic

The nylon parts are made by laser sintering nylon powder which results in parts that are strong and flexible. The surface is also relatively hard, certainly harder than styrene. The sintering process fuses the nylon particles together resulting in a rough sand-like surface which is also somewhat porous. This is good for simulating cast parts, but quite a bit of finishing work is needed for a smooth surface. In addition, the minimum layer thickness of 0.12 mm means the layer-by-layer creation of a part can result in noticeable step contouring of the surface. Orientation of the part in the printing process can minimize this stepping, but it is unavoidable for curved parts such as fenders. Shapeways does offer an inexpensive polishing process, using 5mm cylindrical pellets. This improves the surface finish but it results in the loss of approximately 0.1mm of surface detail.

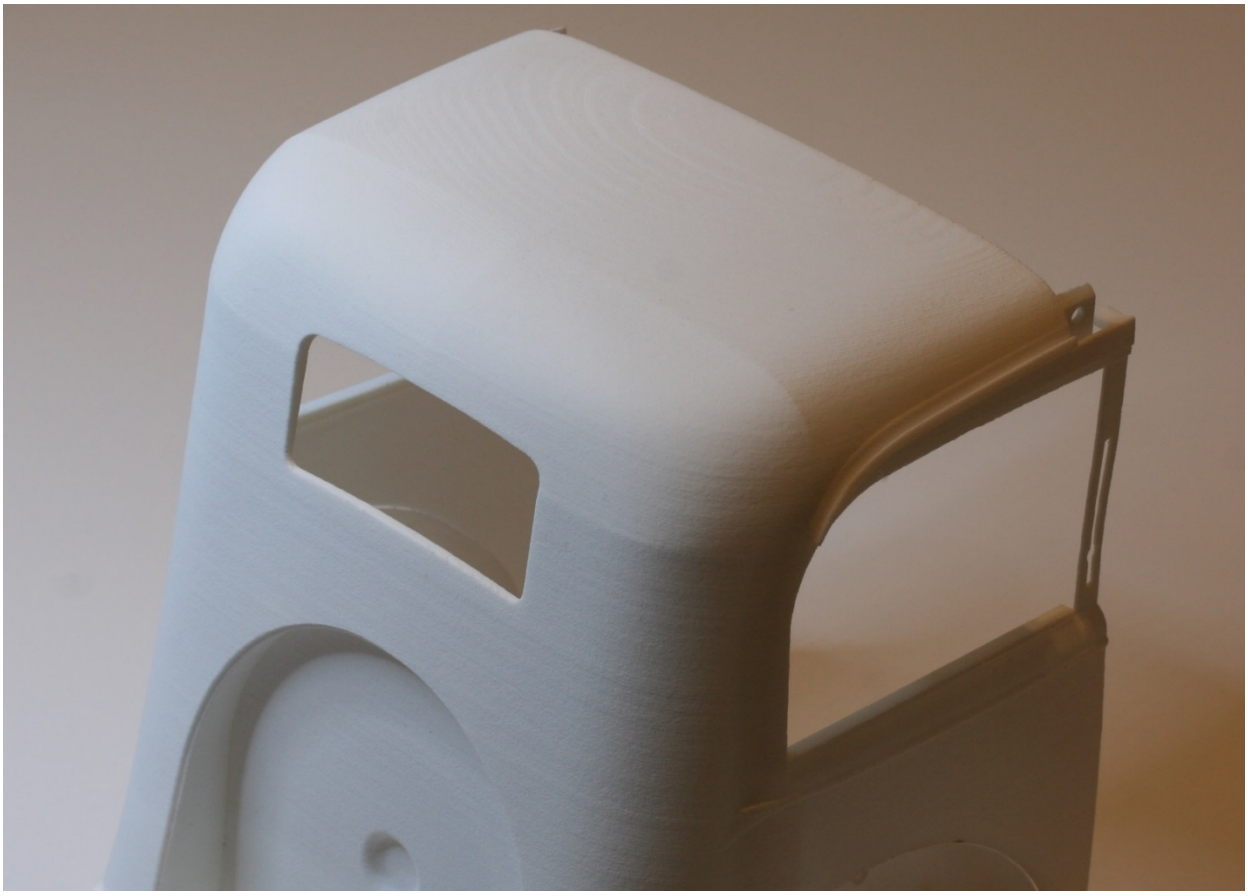
Acrylic offers a significantly higher level of detail but is approximately 2x to 3x more expensive than nylon.
The parts are also more brittle, so thin sections and protruding features needed to be treated with care.
The base level of acrylic parts are made with an acrylic-based photopolymer. Stepping is similar to nylon but cleaning up the parts is easier. A wax-like support material is also used which must be removed before shipping. This cleaning process and the relatively brittle material limits the minimum unsupported wall thickness to 1.0mm.
However, if higher levels of detail and finish are required, Shapeways offers a UV-cured acrylic polymer with the option of choosing 0.029mm (29 microns) or 0.016mm layers. Layering is therefore much less of an issue and although the minimum unsupported wall thickness is 0.6mm, a supported wall thickness can be as thin as 0.3mm.

Here's an abbreviated tabular summary of the main characteristics of Nylon and Acrylic:

Plastic Materials					
		Nylon	Acrylic		
				UV-Cured	
		Laser Sintered	Photo-Polymer	Ultra	Extreme
Min. Layer Thickness	mm	0.120	Unknown	0.029	0.016
Min. Wall Thickness					
Unsupported	mm	0.7	1.0	0.6	
Supported	mm	0.7	1.0	0.3	
Min. Unsupported Wire	mm	1.0	1.0	0.8	
Min Detail					
Embossed	mm	0.2*	0.2	0.1	
Engraved	mm	0.2*	0.2	0.1	
Clearance	mm	0.5	2.0	0.05	
		* 0.5mm for readable text			
Min. Escape Hole	mm	4.0 (or 2mm x 2 holes)	10.0	4.0 (or 2mm x 2 holes)	
Accuracy (+/-)	mm	0.15	0.10	0.025	
Approx. Price Index		100	180 - 280	300 - 350	350 - 500

Rough Finishing Nylon Parts

Here's a picture of a large part (the rear body shell for the Austin Seven). If you look carefully, you'll see noticeable layering and stepping. Unfortunately, the part is too large for Shapeways' polishing process so the layering and stepping imperfections are pronounced and will become even more pronounced once paint is applied.



These need to be addressed before final finishing is attempted.

Wet sanding with 100 grit sandpaper is effective at removing ridges and step lines. The drawbacks are that it can be a slow process, it's hard to be precise and the sanded surface will still be somewhat rough. An alternative is to scrape off the excess material using an Xacto knife blade and then wet sand with 200 grit and 400 grit paper.

For hollows, re-contouring or general surface irregularities, an automotive filler such as Evercoat's Poly-Flex is very effective. Poly-Flex is a flexible polyester glazing putty that bonds well and works well with flexible nylon and can be wet

sanded with 400 grit paper to a fine finish. The putty is also strong enough to hold an edge. Finally, one or two coats of filler primer, wet sanded with 400 or 600 grit paper, will provide a good base for final finishing.

Rough Finishing Acrylic Parts

Acrylic parts are softer than sintered nylon so one very effective way of removing stepping and other surface artifacts is to scape them off using a #11 Xacto blade. The blade provides very precise control and, done carefully, a smooth surface can be created that that requires only light sanding to finish. For hollows, re-contouring or general surface irregularities, Evercoat's Poly-Flex automotive filler again works very well.

Final Finishing

Once the irregularities have been removed, coat the part with a filler primer or a sandable primer and wet sand with 400 grit or finer. Repeat this process until the surface is completely smooth. Then apply a final primer sealer coat and wet sand with 600 grit or finer.

But a word of warning. Over the last few years, many paint manufacturers have reformulated their consumer paints in response to EPA requirements to limit VOCs. For example, I found that some primers with the same name, from the same manufacturer and for the same application behaved quite differently than their predecessors. Sure, the graphics on the can were different, but there was nothing else to indicate the nature of the change.
Eventually, after some experimentation, I settled on using Rustoleum's Filler Primer (#249279), which is available from auto parts stores and other outlets, and Automotive Touchup's Sandable Primer available online from www.automotivetouchup.com. Both work well with acrylic and nylon and both dry quickly.