How Does Automating 3D Printers Change the Break-Even Volume for Spare Parts?

OVERVIEW:

In order to increase the lifespan of appliances, in many parts of the world, right-to-repair laws now require appliance manufacturers to stock spare parts for 10 years after releasing a new product. With some product life spans as low as 2 years, this is a dramatic change for some suppliers, leaving them scrambling for solutions. The current inventory solution is crude: miles of warehouses with millions of spare parts.

3D printing has typically been used as a prototyping tool, but with advancements in automation technology, high-volume 3D-printed production is a real possibility because large batches of parts can be produced in-house with minimal human labour.

The typical method to produce plastic parts is injection molding, and for good reason. Injection molding is well known for being the most efficient way to produce large quantities of custom plastic parts. For an initial production run, it makes a lot of sense to use injection molding to produce thousands of plastic components, but for spare plastic parts, it can be prohibitively expensive and wasteful. This is where the benefits of 3D printing start to appear.

Plastic components typically fall into the category of parts that rarely need to be replaced yet make up a large percentage of the total inventory. Due to this, vast sections of warehouse space are being used to stock thousands of parts which simply collect dust. At the end of the 10-year lifespan, any remaining stock is waste, and will be disposed of. It can be hard to predict how often certain components will fail, and because of this, manufacturers will overproduce spare parts, and this essentially guarantees some level of waste.

Imagine a future where plastic parts are made to order. In the middle of the night, as a new order arrives, a 3D printer immediately activates and begins printing a seldom-requested plastic latch component. In the morning, the part is ready to be collected and sent out to the customer. No warehouse, no waste.

BENEFITS OF A DIGITAL INVENTORY

1. Freedom in Design

When 3D printing a part, there are much fewer design constraints compared to injection molding. Due to this, multiple injection molded parts can be combined, reducing part count. Any design changes can be seamlessly accommodated, and many parts designed for injection molding are easily adapted for 3D printing.

2. Minimum Order Quantity: 1

Injection molding comes with high tooling costs, making it impractical for short runs of parts. Typical molds start at $10k. 3D printers can be used to create any part at all, and in any quantity. Imagine your supply of parts runs out at year 9, and you need to supply an extra year’s worth of components. Do you fork over the cash to do a small batch of injection molded parts? Now it is possible to simply 3D print your parts to fill any gaps in the inventory.

3. Smaller Warehouses

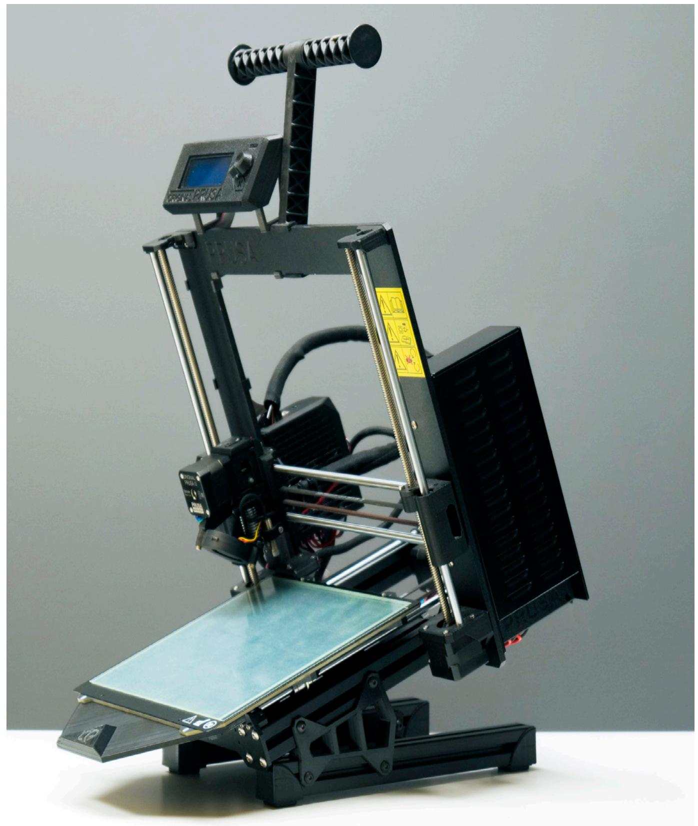
Since 3D printers are small, there exists the real possibility of re-working an area of a warehouse to become a small 3D print lab. Due to the power of automation, just a few 3D printers working 24/7 can be sufficient to meet the spare-parts demand for hundreds of components. Spare parts are usually ordered in small quantities, so it is reasonable to expect that 3D printers will have sufficient capacity. If production needs to be increased, it’s as easy as adding a few more printers.

4. Sustainable

As the climate crisis continues, it is extremely important to look towards sustainable technology that reduces carbon emissions. 3D printing reduces emissions from shipping as operators can 3D print many of their parts in-house, avoiding shipping from overseas contract manufacturers.

WHAT ABOUT AUTOMATION?

3D printing is well known for being a slow manufacturing process, however the main bottleneck for 3D printing in mass-production is not the print speed. In fact the requirement for intermittent manual labor is the main concern. When a print is finished, someone must walk up to the printer, remove the part, and start the next print. And as humans, we are busy. Prints can sit idle on the build plate for hours, especially if prints finish in the middle of night.



The bottleneck has been solved with advancements in automation technology. 3DQue has developed an FFF/FDM 3D printing automation system known as Quinly. With Quinly, 3D printers can automatically eject parts from the build plate and begin the next print. This allows the production of 3D printed components to continue 24/7, only interrupted by the need to reload material once per week, per printer.

It is still true that 3D printers are slow, however that is just a single machine. For the cost of an average injection mold, spare parts suppliers could instead invest in multiple 3D printers which can manufacture anything in their inventory that is suitable for 3D printing. Since there is minimal human labour involved, automated 3D printing is highly scalable, and there are multiple logistical benefits as well.

COMMON CONCERNS

By now, you might have come up with a few counterarguments against 3D printing as a viable alternative to injection molding, and I don't blame you. We're talking about a paradigm shift here, diverging from a tried-and-true method that has worked, and will continue to work for the foreseeable future. The big question is, can we do better? Should we even try? We're human after all, so the answer should be yes! Here are some common concerns with 3D printing, so you don't have to write in, asking us about them.

1. Look & Feel

There is also concern that 3D printing materials lack chemical and heat resistance. Yet, there are many new materials for 3D printing that have these protections such as, PP, PC, fire retardant ABS, and PVC. New materials are constantly being developed, and for example, metal 3D printing is a real possibility with automated 3D printers as well. Metal prints will require a secondary manual sintering step.

2. Strength

Let's face it. 3D printed parts have layers. This is the most common concern, but it really shouldn't be. The look of layers is completely inconsequential for internal components that rely solely on functionality. And external components? 3D printing has come a long way in the past few years, and it is entirely possible to create beautiful parts that are strong and functional, with layers that are smooth and consistent, and sometimes even unnoticeable.

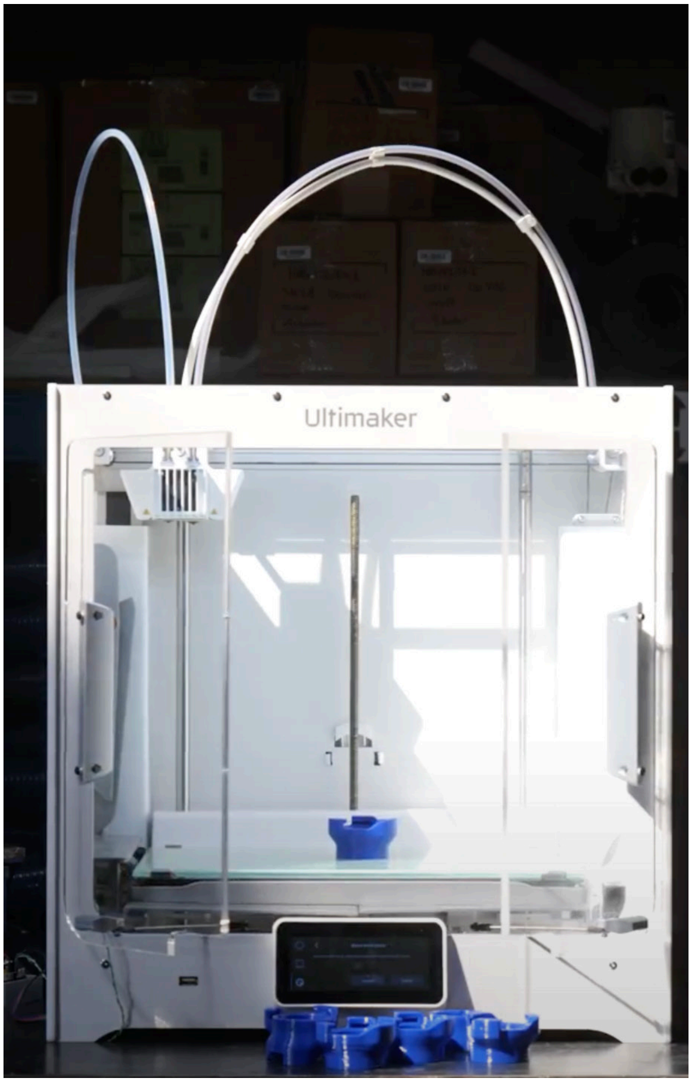
3. Material Choices

As material properties may change during the printing process, the strength of 3D printed parts is often put into question. However, when following "design for additive" guidelines, the majority of 3D printed parts are perfectly suitable as end-use parts. Just as parts need to be designed specifically for injection molding, parts properly designed for 3D printing can almost always be printed in an optimal orientation that negates the inherent weakness of the layer lines. Engineering-grade materials such as carbon-fiber nylon and polycarbonate are widely used in high-strength 3D printing applications.

Case-Study:
Break-Even Cost for a Washing Machine Part

It’s hard to fully realize the power of 3D printing automation without analysing the cost per-part. This simple example should demonstrate that part quantities up to 300,000 (!) are viable by automated 3D printing compared to injection molding.

For this example, we’ll look at an agitator dog found inside many washing machines (Whirlpool part# 80040). This small component is part of a ratcheting mechanism which spins the agitator. This part is made entirely of plastic, and slowly wears out over years of use. They are commonly sold in sets of 4, so we will print them in sets of 4.



Printer Costs

Since 3D printers can print any part at all, it isn't a sunk cost like an injection mold, it is more of an investment. As more parts can be 3D printed, the printer itself becomes more valuable. Let's assume a small print lab costs $50,000. If there are 100 different parts that can be 3D printed, then this cost could be distributed among those 100 parts. In this way, we can consider the "tooling cost" for each different part to be only $500. Considering high-volume injection molds typically cost a minimum of $10,000, then this is a significant improvement.

Material Costs

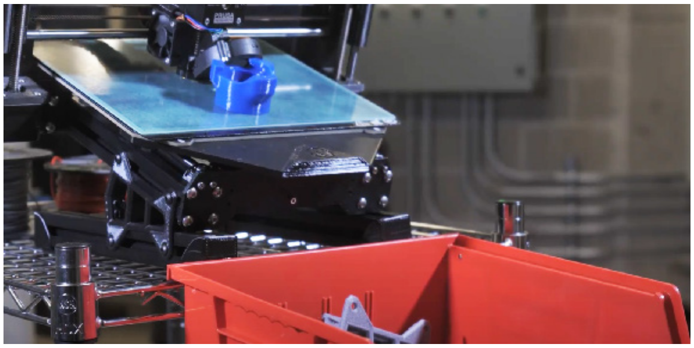
Each part needs 1 gram of material, and 10 minutes of print time. Since this part is a functional internal component, we printed it in nylon for durability and wear resistance. A set of 4 will take 40 minutes to print and use 4 grams of material. Even when 3D printed, the surface finish looks very nice and will work just as well as the original injection molded part. Considering material cost is $0.04/part and 3DQue automation costs an average of $0.02/hour for standard FFF 3D printers, it costs about $0.06 per-part to manufacture them this way.

Labor Costs

Manually 3D printing thousands of parts is infeasible since someone would need to come to the printer every cycle to restart the print. If it takes a human 3 minutes to restart a print, then the cost per-part increases almost 5x becoming $0.28/part, assuming you're paying the operator $18/hr. With an automated 3D printing system, this labor cost is almost entirely eliminated.

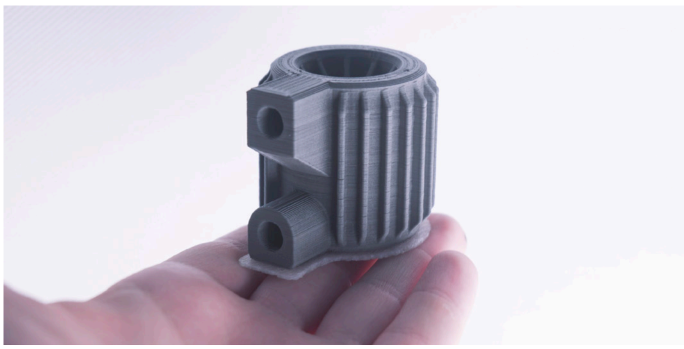
The only labor cost with automated 3D printing is reloading the 3D printing material when it runs out. Assuming 5kg spools of filament, and 5 minutes to reload material, this results in a negligible $1.50 per 5000 parts.

With manually operated 3D printers, one way to reduce labor costs would be to print huge batches of parts at the same time, however this method is prone to failure. If one part fails, then the rest fail too. In practice, batching like this ends up being unreliable.



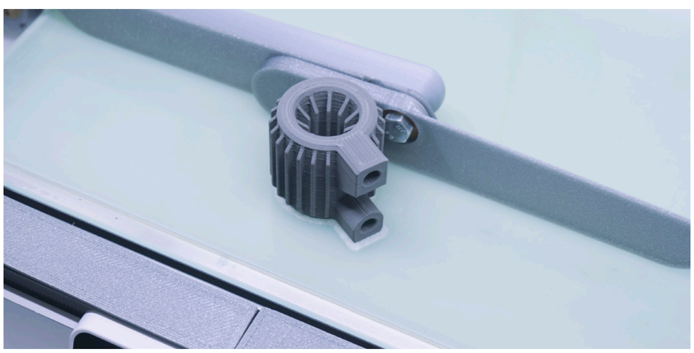
Downtime Considerations

With automated 3D printing, orders can be received in the middle of the night, and parts begin printing automatically. Production can continue through the weekends too. With a manual 3D printer, machines might sit idle overnight, with a backlog of orders waiting for the operator in the morning, causing delays.



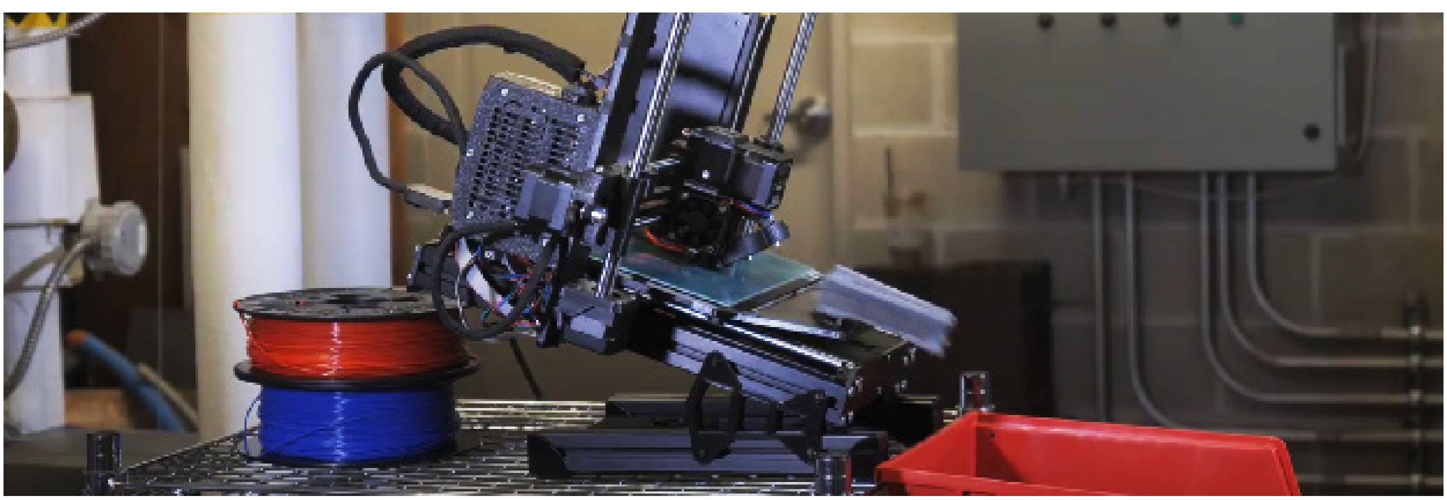
Post-Processing

3D printed and injection molded parts may require some amount of post-processing, however for optimized 3D prints, no post-processing at all is required. Since it is hard to quantify the cost of post-processing for injection molded parts, we will neglect it.



Injection Molding

We're not experts in injection molding, so we will use conservative estimates for the costs involved. In fact, the only cost we will consider is the cost of the mold itself. Material costs for injection molding are neglected in this analysis, so we're being generous here. Let's assume that we can get 50,000 parts manufactured for $12k in mold costs, and 300,000 manufactured for $18k.

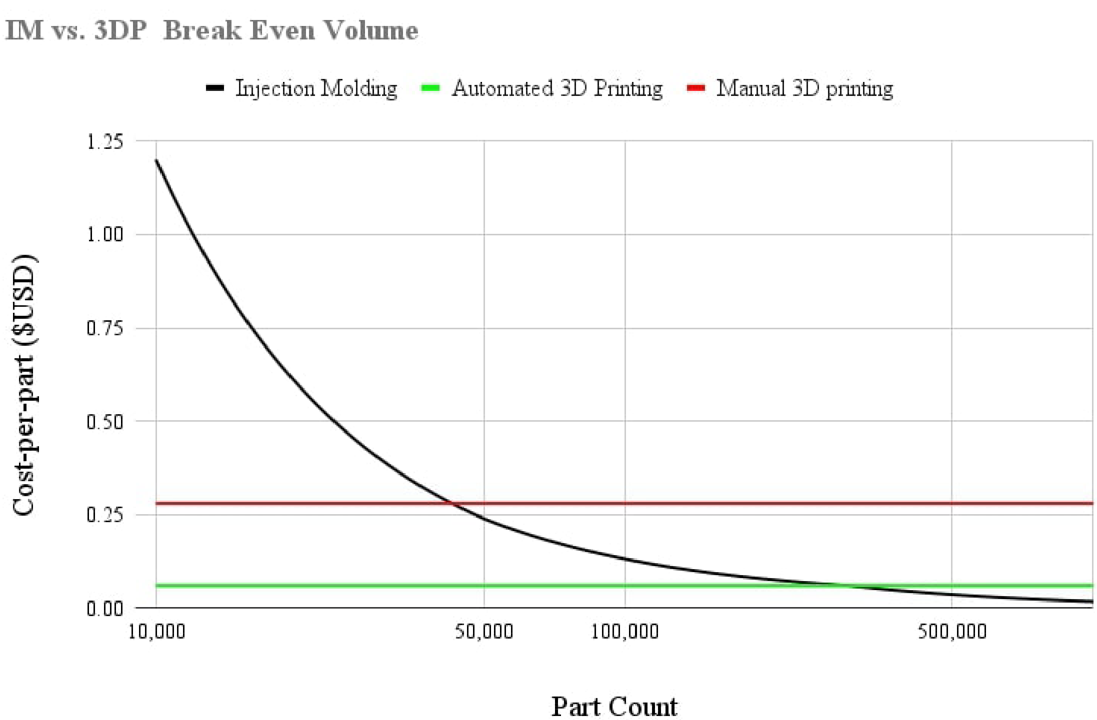


Results

From this initial analysis, and using conservative estimates, automated 3D printing can be competitive with injection molding with part quantities of up to 300,000. This is likely a rough upper bound since the parts in question are quite small, however this proves the effectiveness of 3D printing as a solution for spare parts.

Production Method	Cost/Part ($USD)
Manual 3D printing (Qty. Any)	$0.28
Injection molding (Qty. 50k, Mold $12k)	$0.24
Injection molding (Qty. 300k, Mold $18k)	$0.06
Automated 3D printing (Qty. Any)	$0.06
Retail price (4 pack)	$1.25-$5.25 depending on vendor

The break-even volume isn't the end of the story. Benefits of a digital inventory go further than the cost-per-part. Keeping a lean inventory by printing on-demand will show significant logistical benefits, and the flexibility granted by 3D printing is highly valuable as well. The ability to print low volumes at low cost is now possible due to 3DQue's 3D printing automation. This is just the beginning of the next phase of the industrial revolution.



Author Bio

Steven McCulloch is the Product Lead at 3DQue. His background is in mechatronics engineering, and he guides the product design and marketing direction of 3DQue's flagship product. Looking forward, he is working to establish automation as the next step in 3D printing technology.

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