3D Printing Research Proposal

Prosthetics Manufacturing Inc.

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Abstract

As technology continues to grow we will inevitably reach a point in our company when we need to update our machinery. We advise to consider 3D Printing as our new form of manufacturing for our prosthetics. 3D Printers are accurate, able to create almost any intricate object, and can make products out of different types of materials. This research will prove that the benefits will outweigh the risks.
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Introduction

Our proposal is to exhibit whether or not 3D printing would be beneficial to our company. As a company competing for customers, it is important to explore new technologies that may offer greater efficiency to our company.

Currently

Currently we rely on molding to produce the right shape for our customers. Our prosthetics are shipped to us from a contracted company, namely Prosthetics Manufacturing Inc. The patient goes to a Prosthetics Manufacturing Inc. location to get a mold and fitting for the new prosthetic; the new molding is then shipped to our company. The shipping time takes 4 to 6 weeks. The patient then does all other treatment with our doctors and physical therapists. While this has been an effective process for our business, 3D printing offers the same kind of opportunity but decreases the amount of time it takes receive the prosthetic, i.e. eliminates the 4-6 week manufacturing and shipping waiting period.

What is 3D Printing?

A 3D Printer is a new technology that can be simply explained. We can describe it by first looking at a regular ink printer. Traditional printers print shapes, words, and pictures with various shapes, sizes, and colors on a 2-dimensional plane. A 3D printer works the same way but on a 3-dimensional plane while having the ability to print out different material, analogous to a typical printer printing different colored ink. Designs are made using Computer Aided Design (CAD) software or can sometimes be downloaded from open-source websites specific to 3D printing. The potential on what can be designed and printed is theoretically limitless.

What makes 3D Printing Unique?

3D Printing does not inject materials into a previously formed mold like traditional prosthetics manufacturing. This is important because it doesn’t limit what designs can or cannot be created. Not only this but 3D printing can create objects of almost any material, and new printing material capabilities are being offered each year. 3D printing benefits the manufacture because the intricacies of the inside of an object can be produced simpler. For example, an engine has a labyrinth of valves and cylinders, which in order to be created using moldings needs to be created in pieces and then assembled together. A 3D printer however, can create objects in one
Different Types of 3D Printing

Throughout our research we found that the techniques a 3D printer uses can be generalized into the following methods: Photopolymer, Lamination, Granular, and Fuse Deposition Modeling.

Photopolymer

Photopolymer materials are a specific kind of liquid material that, when exposed to a certain light, will rapidly change into a solid. This kind of production is very useful in the additive manufacturing industry (See Figure 2).

Lamination

This form of manufacturing is basically taking the design of an object, cutting it into thin slices, and combing the final product using some form of adhesive or glue. There are many kinds of materials that fall under this category such as metallic foils, plastic films, and even something more organic like paper (See Figure 3).

Granular

This technique is used to manufacture objects in the form of metals, plastics, and even certain types of ceramics. The material being used starts off in a granular form. This form can be solidified in different ways by adhesives, melting, or sintering. Generally speaking, plastic is usually kept in a granular form and later turned into a solid by applying an adhesive. The way the adhesive is applied is through an ink-jet spray. Granular metal, on the other hand, is heated greatly and combined together to become solid (See Figure 4).
Fuse Deposition Modeling

Fuse Deposition Modeling or FDM, is one of the most common types of additive manufacturing. This approach can be compared to a tube of paste being squeezed layer by layer to form an object. This form frequently uses thermoplastics, i.e. pre-plastic material that fuses when melted and hardens to become plastic, because it is easier to mold and shape (See Figure 5).

Problem

3D printing can offer simple made, in-house manufactured prosthetics for our company. “3D printing offers significant cost efficiency, as well versatility. The speed with designs can ... open many doors” (3d Printing...We know it) The benefits are speed and cost savings, the problem is that this new technology has the potential of taking over future manufacturing for major product-producers and we don’t have it. It is crucial for any company to be on the forefront of new technology germane to their business for competitive reasons. It is our responsibility to consider all options that may offer greater efficiency.

Discussion

Currently our company relies on Prosthetics Manufacturing Inc. for our feet, pylons and aesthetic features to be manufactured. The majority of these parts are not custom-made but rather manufactured on a large scale in various sizes to be sold in bulk to companies like ourselves. With a 3D printer, these parts would only be made at request, reduce bulk purchases thus being more frugal with expenditures, be more unique to the patient’s limb dimensions, allow the patient to choose materials of his/her prosthetic and limit inventory of sporadic prosthetic sizes. There would be no need for a stock room of components which means no time spent accounting for inventory and no special ordering of components to maintain stock and furthermore, no ordering of components, period. Our company is currently prescribing and providing therapy for the patients. With 3D printing, we can also be the single location for our prosthetics. This can provide the potential for us to make individual designs structured around the patient thus reducing product ineffectiveness from trying to make Prosthetics Manufacturing Inc.’s design fit every patient perfectly.

Company Autonomy

As stated above, the company will be a single location for patients care. Theoretically, we will provide complete satisfactory prosthetic design and fitting in one day, granted, the physical therapy will still last over several weeks. (Prosthetic Management) We can also offer special purpose prosthesis, e.g. waterproof materials used for showering or swimming.
Current methods of manufacturing and assembling
The current method used by Prosthetics Manufacturing Inc. is to die-cast a titanium pylon. These are made by various lengths and sent to our company. Current method to finish the prosthetic is to pour molten plastic into a mold measured from the patient in Prosthetics Manufacturing Inc.’s office. With 3D printing, different materials can be used, e.g. print a carbon fiber reinforced plastic pylon as well as the plastic mold of the limb, all in one convenient location within a much lesser time frame. So potentially, we are theorizing that patient would be prescribed by our doctors, fitted by a personally designed prosthetic by our prosthetists and be put to the test with the new prosthetic completely supervised by our physical therapists in less than an entire work day for our office. The patients can still continuously see our physical therapists for several weeks thereafter to complete their physical therapy training. The main difference is unique design and potential material use. New model 3D printers are being offered with more material usages. 3D printer making is highly competitive so the market can expect great expansion with even greater potential.

Carbon fiber vs. other materials
Research is abundant in comparing different types of metals with carbon fiber particularly in biking. Because there aren’t many studies comparing the pros and cons of these materials in prosthetic use, we’ve researched their strengths and weaknesses where they are important. The data in this graph, which compares materials, would be used for comparing materials. (See Figure 6).

Silicone is a sealant commonly used against water. In June of this year, a 3D printer has come out that prints silicone. Because it is relevantly new in 3D printing, it isn’t offered in all models of printers. Silicone can be used for our waterproof prosthetics, theoretically, by making a silicone layer on top of the plastic. Unfortunately this isn’t commonly used in 3D printing so it would have to be a new design created by our company. (Finally), (Silicone)

Comparison of 3D Printers
Large, industrial 3D printers are sporadic in the 6-figure price range. The Objet1000 is a professional, industrial sized printer made by Stratasys, one of the U.S. largest 3D printer makers. It prints objects up to “(39.3 x 31.4 x 19.6 in.)”. (Objet1000) This size would be perfect because it can print objects in one piece that covers all sizes of human legs, even very tall ones. Stratasys requires personal information before getting a quote but the price of the Objet1000 is expected around $500,000 at least.
The Markforg3d model costs $9,000 and prints objects up to “(12.6” x 5.2” x 6.3”)”.
(Markforg3d) It is a unique printer because it offers simultaneous printing of two filaments. Because this machine only 3D prints objects up to 12.6 inches in length, we would likely have to print several pieces to fit together; this wouldn’t be all that unusual because prosthetics come in several pieces already, e.g. fingers for hand prosthetics. The pieces can be printed separately and fastened together using screws. The greatest benefit of the Markforg3d is that it prints carbon fiber reinforced plastics. These reinforced plastics are 20x stronger than the typically used ABS plastics for 3D printing.

Filaments used in the printer are an added cost. The carbon fiber filament is the costliest at $25 a cubic inch while the PLA filament is priced at $.99. (Markforg3d) Other filaments are offered by Markforg3d.

Resolution is acceptable on any 3D printer because the prosthetics we would print are large. Nearly all 3D printers researched, specify at least Windows 7 for the necessary software. Also, nearly all 3D printers require 240V electrical output also; standard output in the U.S. is 120V so a converter would be necessary without it. (120V vs. 240V)

**Conclusion**

Taking all of this information into consideration, switching to 3D printing from molding as the new form of manufacturing will help our company complete tasks quickly and efficiently. By having all the components in our facility, our customer satisfaction will exceed expectations thus giving our future a promising result. We feel certain that this revolutionary technology will strengthen our foundation as a company.
Glossary

ABS/PLA plastic- PLA is a biodegradable plastic while ABS is sturdier but also more damaging to the environment. These are the most common filaments used in 3D printing. (PLA vs. ABS Plastic)

Additive Manufacturing- is taking a 3D model of object stored in a computer, translating it into a series of very thin layers and building the object one layer at a time, stacking up material until the object is complete. (3D printing for Dummies)

Carbon-Fiber- is a strong, stiff, thin fiber of nearly pure carbon, made by subjecting various organic raw materials to high temperatures, combining a strong, lightweight material used in construction of aircraft and spacecraft.

Open-Source- an initiative that allows source codes of programs to be downloaded free while being capable of edits. E.g. www.thingiverse.com offers these downloadable files for 3D printers. (Open Source)

Pylon- a rod-like structure used for support.

Prosthetic Limb- is a device that replaces a tissue or part of the body. Prosthetic limbs have been around for 3,000 years but the prosthetics we use now are made of plastic or metal not wood.

Sintering- the process of making a solid mass by heating or putting it under high pressure without turning it a liquid.

Stereo lithography- uses focused UV light to transform liquid photopolymer plastic into solid form. (3D-printing for Dummies)

Titanium- is a very hard, light-weight, corrosion-resistant metallic element existing in various minerals.
Works Cited


