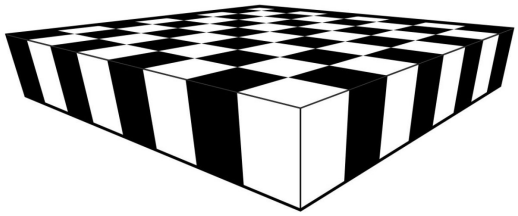
Professor: Jennifer Stamm, PhD
Spring 2020

MAE 364 Manufacturing Processes

Comparative Analysis Project
Gate 1 - Project Planning

Group Members:
Damian Host - 50171722
Vladimir Shapiro - 50181136
Ashraf Hossain - 50138850
James Roetzer - 50184851
Wenzhi Lyu - 50159420
Ayesha Khatun - 50243514



INTRODUCTION

Our project group consists of six motivated engineering students. The first is Damian Host who is the point of contact for this project. The second is Vladimir Shapiro, the project manager. Both Ashraf Hossain and Wenzhi Lyu are technical writers. Lastly, James Roetzer and Ayesha Khatun are technical experts. The team aims to work together to design a hat themed chess set.

PROJECT PROPOSAL

Initial Assessment

The goal of our team in this project is to create a chess set that is creative, intuitive, and within the scope of our resources. With these goals in mind, our brainstorming session ended with hats being chosen as our theme. Hats are an easy way of visually distinguishing status and ability. Two of the most important qualities in a chess piece. Pawns are critical to success in chess, but their job is different from that of the queen. This is analogous to the hard hats of our society. They are necessary, but not extravagant. This is just one example of how our theme can draw parallels between the real world and chess, making it easy for players to understand how to play. There are many directions we can take with the theme, leaving us room to be as creative as we can be.

Our client for this chess set is the New York City municipal building. They want to be able to have a fun themed chess-board that encapsulates all the different working classes and the diversity of the city. The theme that we have chosen is able to meet these requirements in a fun way that can start conversations between the people who visit the building. Since this chess set would be located in the lobby and open for anyone to use it is important to look at the cost of the pieces. People will end up stealing them and therefore it would not make sense to have a high production cost associated with the chess set. Our final design and manufacturing process should be able to look desirable while maintaining a low cost of manufacturing.

The decision is supported by our technical skills and knowledge of manufacturing processes. Because hats come in various shapes and sizes, we will have many options to choose from when designing 3D models and manufacturing. We are free to consider the challenges of designing and manufacturing without the risk of getting stuck with no alternatives. Many hats have a relatively simple geometry, which helps lower manufacturing complexity and cost.

Work Proposal

We will begin our design process by researching existing manufacturing processes that are used to create chess pieces. By doing so, we will be able to compare between different processes and choose the most feasible one. Different methods will have different processes. Cost, machinery, labor, manufacturing time, and etc. depends on the chosen method. After choosing the best method, each team member can choose a distinct chess character and design the character by sketching, creating a digital 3D model, and then creating digital drawings. By using pictures and actual hats as inspiration the pieces can be created more realistically. During the group meetings, we will discuss the design of the body of each character. This will involve deciding on the type of hat to represent each character, size of the overall body, size of the hat, the weight of the body, structure, and support, aesthetics, and more. After the design is approved by all members of the team, we will proceed towards prototyping. Additionally, we will research the market involving our theme, and change aspects of our design if needed.

Management Proposal

To be able to effectively complete the required work for each stage in the project there will be a structure to our group. The most important aspect of a good working team is effective group meetings. Our group meetings will be held weekly in order to not fall behind in the work that needs to be completed. The goal for the next meeting will be discussed during the meeting before so that everyone knows what work will be done in the next meeting and also what work needs to be completed in between them. This method is very effective in many ways. Firstly, everyone will know what work they need to complete before the next meeting, or an alternative deadline decided upon as a group. Secondly, time will not be wasted during the meetings for people to finish work that needed to be done beforehand. By utilizing this method our group will be able to complete all the project requirements.

There are two types of group conflicts that need to be addressed in order to have a functioning team. The first of which is a timing conflict, where someone cannot meet during a predetermined meeting time. One way to handle this situation is to try and move the meeting to a different time that works for everybody. If that cannot happen then we will move forward with the meeting but make sure to take detailed notes on what they missed. We will make sure that the member who missed the meeting receives this information and knows what work is expected from them. The second conflict to consider is the disagreement between two or more members of the group. The way these conflicts will be handled will have to differ from case to case, but a general process will be used. This will consist of the feuding groupmates expressing

their opinions to the rest of the group without being interrupted. Once both parties speak, the rest of the group will be able to ask clarifying questions and try to come to a conclusion that will be able to accommodate both parties involved. By using these methods to resolve conflicts our group will be able to stay on track and complete work in an efficient and friendly manner.

BACKGROUND RESEARCH

Chess Set Background and Styles

Chess sets have a long colorful history that has led to the modern iteration of chess as a game. The modern “Official” chess set is itself a style dating back to the 1800s. The Staunton Chess Set, created in the 1840s, is the required style for official or tournament matches and is typically the style of set people imagine when thinking of chess pieces. The Staunton chess set style is not entirely uniform, with certain variations existing between particular instances of sets [1]. Thousands of other chess styles exist, both historically and in the modern world. While historical variations may have changes in rules, modern chess set styles instead often vary in aesthetics to match popular culture, or may even act as art pieces. Such modern custom chess sets can become highly abstract in design, with very little to determine the different pieces other than certain official guidelines [1].

Modern chess sets do not vary between styles even if the pieces change shape. Each chess set is comprised of a black set and a white set of a king, a queen, two rooks, two bishops, two knights, and eight pawns. The King is the tallest of these, and all other pieces are made in proportion to the king. According to official chess standards, the king should be approximately 10 centimeters in height, with the width of the piece being around 50% of the height. Furthermore, the squares on the chessboard should then be approximately 1.25 times the diameter of the base of the king. According to the official rules for chess, the chess pieces should be bottom-heavy to avoid tipping over easily, which can be accomplished with the overall design, adding weights, or having a felt bottom to increase friction [1].

Compositionally, the standard Staunton chess sets are typically made of wood or plastic, colored to match the black and white side of the board which the piece will belong to [1]. More abstract chess sets may use unusual materials, such as bone or glass, or colors, such as red and brown. Often, these sets are ornamental or artistic ones but are still playable chess sets outside of tournament play.

Additive Manufacturing Limitations and Advantages

The additive manufacturing method, more commonly thought of as 3D printing, is composed of many processes, such as melting, sintering, solidifying, etc. Through these processes, the material is shaped layer by layer into the final structure [2]. Thus, additive manufacturing methods enable designers to create parts with complicated structures easily. Another important advantage of the additive manufacturing method is that the lead time is much shorter than the traditional manufacturing process, where special tools are needed prior to creating a prototype. Furthermore, unlike traditional manufacturing processes, additive processes do not require the user to have complex skills [2]. However, the user must be knowledgeable in using modeling software such that the designs of the part to be printed are made.

There are also many limitations to consider when using additive manufacturing methods. First, the cost of a high-end 3D printer with industrial-grade accuracy is much greater than traditional subtractive machines such as mills, drill presses and lathes [2]. Also, the surface finish of the parts created by certain 3D printers are pretty rough, and additional work is required to create a more usable part or product. Moreover, due to the potential defects and the layers, the products usually have very poor mechanical properties. This is due to the orientation of the layers because the layers are placed on top of one another facing the same direction the product is not isotropic [9].

As mentioned in the beginning, the group is planning to use different types of hats to represent the different chess pieces. With the help of an additive manufacturing method, the group can design and create hats with very complex forms. Furthermore, the prototype can be created immediately for the group to examine if the hats fit the bodies of the chess pieces or if the parts work out as designed. However, considering the limitations of 3D printing, the group might need to consider if it is necessary for the design of the chess set. Below you can see how additive manufacturing works and how in prints from the ground up.

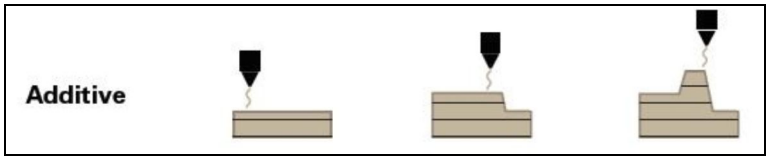


Figure 1: Additive Manufacturing Process [5].

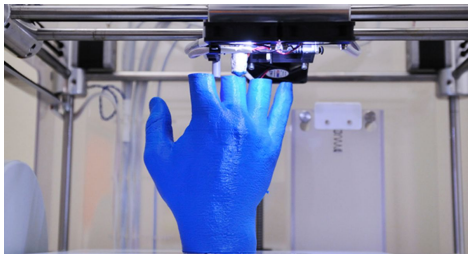


Figure 2: 3D printing [8].

Subtractive Manufacturing Limitations and Advantages

Subtractive manufacturing is a method that involves starting from a chunk of the chosen raw material and removing material using a sharp cutting device until the desired shape is obtained. Chess pieces can be constructed by turning the desired chunk of material and shaping it with a lathe [7]. Drills can also be used to remove material from secured chunks to create holes and other shapes that cannot be created using a lathe or similar method [7]. The most common materials that chess pieces are made of are wood, glass, and steel [10]. These materials are able to undergo the same methods of shaping using the same machine, but it is important to use the right cutting device for the specific material. Below is a diagram of how the subtractive manufacturing process works and some real-world applications of the different machines used with this method.

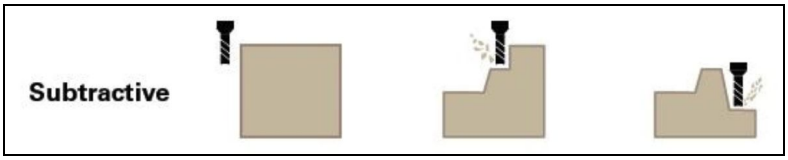


Figure 3: Subtractive Manufacturing Process[5].

Figure 4: Subtractive manufacturing methods [4], [7].

Subtractive manufacturing has many advantages over more recent additive manufacturing processes. Unlike additive methods, subtractive methods can be used to manufacture products on a large scale [2]. The machines used for this method are easy to have an assembly line that allows for large scale production. Additive manufacturing

also takes a long time to print products that are reasonably large, which would hinder large scale production, making subtractive manufacturing better. Unlike additive manufacturing, subtractive methods can utilize all the machines listed above and more in order to create a finished product on a wide array of materials [2]. The cost associated with subtractive methods is also much lower than additive methods. This decrease in cost is due to the availability of standard machines and labor costs since it takes less time to create a product using this method.

Subtractive manufacturing also has some downsides associated with it. One of the downsides is the amount of material that is wasted while creating a product [2]. Since you have to start out with a block of raw material larger than the finished product, the amount of material wasted can be significant. In our case of chess pieces, this would not be a lot since the pieces are very small. But in large scale productions, this could add up to a large amount of material being wasted. This method also requires more labor than additive manufacturing [2]. Workers have to be present to use most machines in this method. Unlike additive manufacturing where the machine is programmed and you just let it build the part over time. More expensive pieces of equipment can do the same thing in subtractive manufacturing but it comes at a cost. Subtractive methods usually are not as precise as additive methods, which can lay very fine layers [2]. Another downside of subtractive manufacturing is that it is not possible to create a product that has a varying density throughout [2]. Separate parts of different materials would have to be constructed and attached to one another to achieve this effect. On the other hand, additive manufacturing could be used to do this and all that would have to be done is have the printer change the material being used at a given instant.

In the case of our project, subtractive manufacturing methods could be used to create the chess pieces. Different mills and lathes could be also used to create our desired shapes out of blocks of raw material. However, we must consider how precise the machines are if we decide to create chess pieces that have a complex geometry.

REFERENCES

[1] Just, Tim. Burg, Daniel S. 2003., U.S. Chess Federation's Official Rules of Chess (5th ed.), McKay, ISBN 0-8129-3559-4

[2] Additive Manufacturing & Subtractive Manufacturing: Pros & Cons, Applications. (n.d.). Retrieved February 17, 2020, from http://www.minaprem.com/machining/introduction/additive-manufacturing-subtractive-manufacturing-pros-cons-applications/

[3] *Most Satisfying Machines High-Speed Metal Milling*. (2018). Retrieved from https://www.youtube.com/watch?v=Sbs5BjM4wgk

[4] *Modern High-Speed Cnc Lathe Machine Working, CNC Milling Machine Metal*. (2019). Retrieved from https://www.youtube.com/watch?v=jF4F8Zr2YO8

[5] Nano, B. (2019, August 28). How Can 3D Optical Profiling Optimize Additive Manufacturing Processes? Retrieved February 17, 2020, from https://www.azom.com/article.aspx?ArticleID=17901

[6] *Chessboard*. (2018). Retrieved from http://jdh.hamkins.org/chessboard-in-perspective/

[7] Best Wood Lathe On The Market For Woodworking 2020. (2019, August 2). Retrieved February 17, 2020, from http://mytoolcloset.com/best-wood-lathe/

[8] Salisbury, D. (2015, July 24). Experts address promises and problems of 3D printing large structures. Retrieved February 17, 2020, from https://news.vanderbilt.edu/2015/07/24/experts-address-promises-and-problems-of-3d-printing-large-structures/

[9] 3D Printing Settings Impacting Part Strength. (n.d.). Retrieved February 17, 2020, from https://markforged.com/learn/3d-printing-settings-impacting-part-strength/

[10] The Editors of Encyclopaedia Britannica. (2017, May 25). Chess piece. Retrieved February 17, 2020, from https://www.britannica.com/topic/chessmen