Design for Manufacturing, Reliability, and Economics

Team No. 20

Development of a Consumer Grade Levitating Hoverboard

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ABSTRACT

After several months of research, Group 20 has narrowed the selection process of a levitating hoverboard by analyzing the market need from various tables and charts of data. Using the HOQ and morphological chart, three designs were analyzed and one was adopted by the team. The components for the design were ordered and construction of a prototype has commenced. The Failure-Mode and Effects analysis must be performed on the prototype; as well as, a risk assessment and operations manual drawn up. Similar to a start-up company, a product is introduced, in which the company has done extensive research before-hand to ensure that no failures will occur and that the economics and profitability of the design are sound. This stage is known as the research and development of the product. The next area that requires analysis is the manufacturing side, and how each sub-component will be made or if the component will be supplied from a vendor. In the upcoming months, the levitating hoverboard will be introduced and provide safe entertainment to children and adults around the world.

1. Introduction

The idea of some kind of levitation hover board was unheard of until the movie: Back To The Future was filmed in the 1980's. Throughout the series, Marty McFly traveled around town on his hover board, which looked very similar to a skate board, but with no wheels. Since then, scientists, engineers, handymen, and others have attempted to create an actual performing model, but few have truly succeeded. In recent news, Lexus successfully created a hover board made from super cooled magnets and liquid nitrogen. Though, the track they tested their prototype on had magnets underneath the surface to help oppose the force, hence the levitation. Another company that created a successful levitation hover board is Hendo Hover [1].

It is a slow transformation, but futuristic looking devices are starting to emerge when it comes to transportation. Nearby locations that do not necessarily require vehicles have allowed people to use bicycles, skate boards, roller blades, and much more. Bicycles have evolved over the years with gear mechanisms and aerodynamics. Skate boards were created as a different means to get around quicker than walking as well, utilizing the board and trucks for steering. Afterwards, scooters emerged, changing the toy industry due to an easier turning mechanism (handle bars). From scooters, Segway created personal transportation mechanisms used anywhere from security to personal use. The latest, possibly the most "futuristic looking" mechanism that has been designed is the hover board, created by HX, though it does not levitate. This design incorporates self-balance to determine speed and direction. One thing is still missing though, the levitation aspect.

It is believed that a design that can include the true levitation affect can greatly alter the transportation industry. This mechanism will include a rechargeable feature in an easy and convenient portable setup. A design has already been constructed, but this will be a base model for further implementation. Studies of aerodynamics can enhance the travel distance; materials will determine costs but conditions must be met whether environmental or any other surrounding conditions so the lifetime of the levitating hover board will last. The many components have been analyzed in previous reports and the design process and manufacturing are being concluded. The manufacturing process will be outlined here along with the risk and reliability analysis.'

2. Design for Manufacturing

The success of manufacturing any product depends on several factors, such as design, materials, production and assembling process. The less complex these components are, the easier and less expensive the product will be. Team 20's prototype is made up from five different components that follow a simple design. These components are a sandwich structure of carbon fiber reinforced plastic with balsa wood in the middle, a wireless rechargeable blower, PVC coated polyester skirt, PVC mount holder for the blower, HH-66 vinyl cement, screws, and a small wood slat. Figure 1 shows an exploded view of the hoverboard's components.

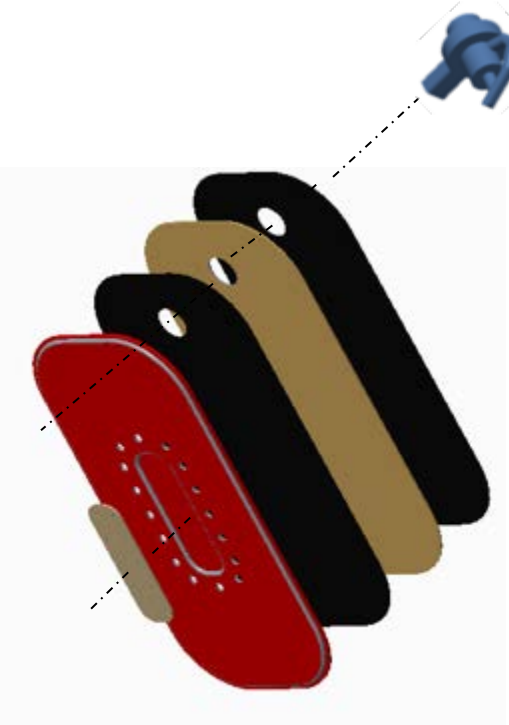

Figure 1 - Exploded View of Consumer Grade Levitating Hoverboard

Looking into the production process and assembly process, the first step is to create the main board for the hoverboard. For this, a vacuum bagging process is used to manufacture the sandwich structure that consists of carbon fiber reinforced polymer and balsa wood in the middle. This process uses epoxy resin and a hardener that together cures during the vacuuming process to provide the final board its properties. When the board it's made, it is cut into the desired shape and a hole with the dimensions of the blower is also created in a specific location.

Following the first step comes the assembly process. The PVC skirt is strategically attached with the vinyl cement into the bottom side of the board and a wood slat is placed in the middle and on top of the skirt with screws. Holes of a specific dimension are opened in the skirt along the side of the wood slat. Furthermore the mount of the blower is attached to the hole on top of the board with the vinyl cement as well and the blower is placed in it.

The creation of the main board takes a day to be ready and the assembly process takes around an hour. This time was anticipated and gives the team an idea of how much time would be needed if the product would be manufactured at a larger scale to meet certain demand of production to be sold. The design operates good with the least amount of components possible, which makes it easier for manufacturing it.

3. Design for Reliability

Under a certain time interval of operation, the hover board will still be in service to the user. The first attempt of operating the hover board was a success in regards to performance and maintainability. The hover board will run smoothly through numerous operations. Using the hover board for more than one hundred operations, the performance will still be great. The hover board is “expected” to operate for sufficient years. However, premature failures are to be expected.

The Failure Mode and Effects Analysis (FMEA) describes what can go wrong with the product and if it did, what it would mean to the overall function of the product. Below in Table [], the FMEA is explained for the hoverboard.

Table 1 - Failure Mode and Effect Analysis

Key Process Step/Input	Potential Failure Mode	Potentials Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended
Skirt	Hole in skirt	Product cannot inflate, rendered useless	10	Foreign object punctured the skirt. (from assembly, or from terrain)	2	Careful assembly Careful riding	3	60	Ensure careful assembly and create a method to fix any problems of this nature
Board	Broken board	Product cannot be ridden, rendered useless	10	Too much weight, Improper use	2	Careful Assembly Careful riding	3	60	Ensure careful assembly and create a method to fix any problems of this nature
Seal	Broken seal	Product cannot inflate, rendered useless	10	Defect in assembly, Eventually wear and tear	3	Careful Assembly Careful riding	3	90	Ensure careful assembly and create a method to fix any problems of this nature

Inflator	Dead Battery	Product cannot inflate, rendered useless, temporarily	6	Battery has run out, Defect, cannot hold charge	5 2	Recharge battery when needed Include new battery in purchase	1	30	Reminder to recharge battery and create a method to fix any problems of this nature
	Broken internal fan	Product cannot inflate, rendered useless	10	Product defect Improper use	2	Warning to not tamper with or open the inflator	1	20	Advise against tampering and create a method to fix any problems of this nature

Sources of failure would come from errors in manufacturing/assembly as well as misuse and poor maintenance. Failure would not occur under ideal operating conditions such as a smooth riding surface, properly charged batteries, and a steady riding position. Since the components of the board are heavily dependent on each other, then the board's operation hinges on each one to not fail. The general pattern in the FMEA below is that components that relate to inflating and lifting the board would severely affect the overall function of the board. Each component of the hoverboard is vital to the operation of the entire product.

Some reliability concerns consist of the battery of the blower, the skirt condition over time, and the skirt HH-66 glue coming apart. Charging the battery continuously affects the battery health and overall effects the performance of the hover board. Under numerous operations, the skirt glue and material has potential to degrade. For the skirt itself, thermal heat transfer from a heat source i.e. the sun, and hole punctures are a concern for the integrity of the skirts life.

To combat these reliability concerns, a warranty can be issued for the first year of operations to ensure user confidence and satisfaction. The battery will be purchased from high end U.S manufacturers that provide tested and quality products. The battery will also be tested individually again to ensure great performance. If the heat of outdoor affects the skirt, a coating can be applied to the skirt so that the skirt life can be extended. There will also be methods to patch holes if any were to arise. If The HH-66 Glue that holds the skirt together comes apart, the user will be provided with a new set of glue. The reliability of the hover board closely corresponds to the overall safety.

It is imperative that there are no compromises to the hover board integrity, so that the user can be safe operating the hover board.

4. Design for Economics

As an entrepreneurial senior design project, the economic side of the project is something essential. One of the main goals was to keep the manufacturing cost low in order to show a more profitable revenue analysis. The total cost of the final product is $280, and its price breakdown can be observed in Figure 2's pie chart. This chart provides a better view of what our most expensive resources are, which in this case it's the blower conforming a 71% of the total price. Following this large percentage is the composite sandwich structure with 18% of the price. The two most expensive components of the board are the most important ones for the product to work. For business purposes a profitable multiplier of three is used to calculate its possible commercial price of $840, which is then rounded up to a final price of $900.

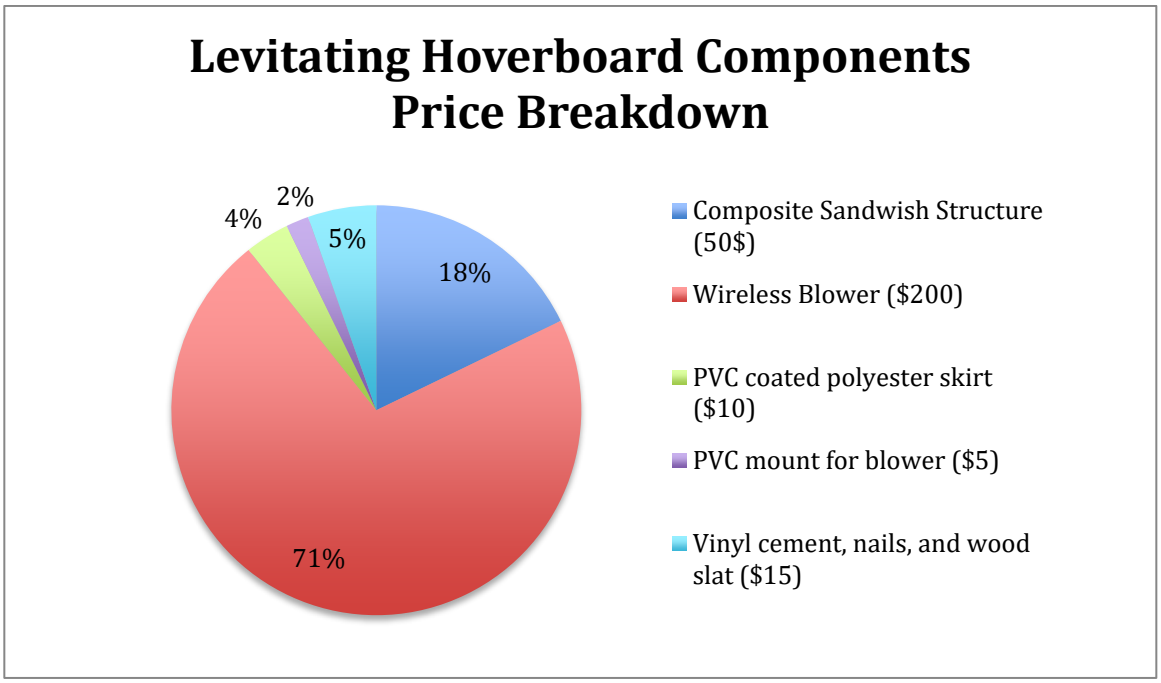

Figure 2 - Levitating Hoverboard Components Price Breakdown pie chart.

The commercial price of team's 20 consumer grade levitating hoverboard might seem a little high at first sight, but the price is incredibly low compared to it's competitors. There are only two commercial hoverboards that are going to be marketed soon, the Hendo Hoverboard and the Lexus

Hoverboard. Both of these competitors are around $10,000 [1]. Taking a look at Figure 3, the bar chart illustrates how much of a fraction the project's prototype price is compared to the competitors.

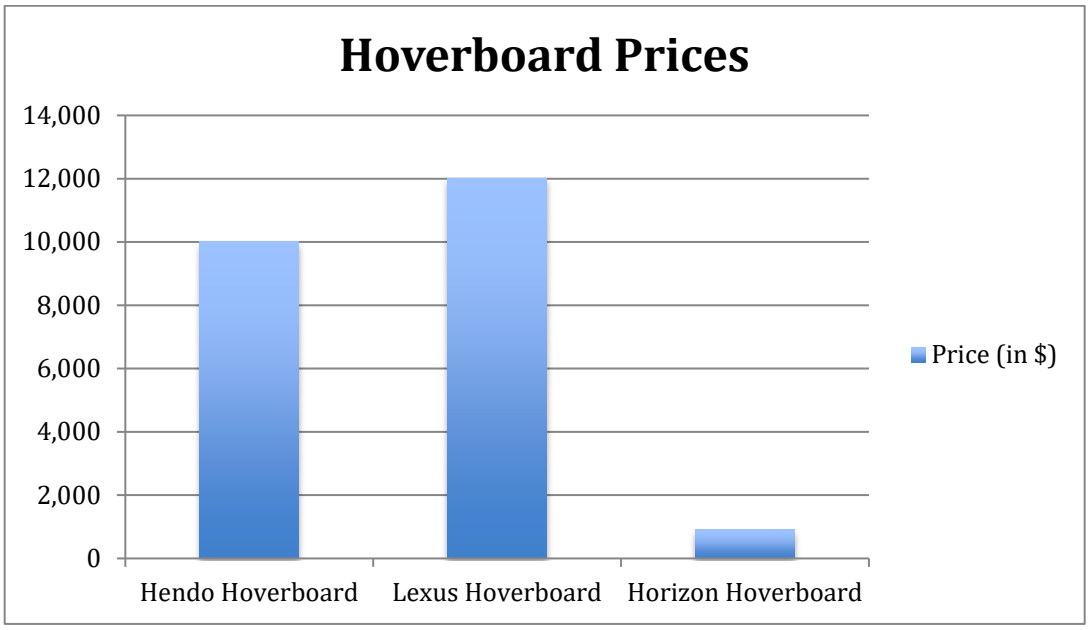

Figure 3 - Comparative Bar Chart of Hoverboard Prices

5. Conclusion

The goal of this project is to innovate and produce a fully-functional, battery operated, marketable hoverboard capable of hovering on a cushion of air. Looking into the design of manufacturing, reliability, and economics in this report, a better understanding of the development of the consumer grade levitating hoverboard is obtained. The final product's manufacturing structure consist on seven different components, from which one is manmade and it's then assembled to the rest of the components. The total time of production for one board y approximately 25 hours, where 24 hours correspond to the creation of the board and the last hour is for assembling. As far as reliability, the hoverboard's performance has a promising consistency throughout the years despite some minor things that might affect it. The price of just one hoverboard costs $280 to be made; if marketable, a price of $900 would be used. This final market price is considerable low compared to the direct competitor's price of over $10,000.

References

[1] "The Hendo Hoverboard." The Hendo Hoverboard. Arx Pax, LLC. Web.

[2] Matthew, Ken. "Global Hoverboard Market Forecast & Opportunities, 2021: TechSci Research Report." MarketWatch. MarketWatch, Inc., 11 Aug. 2016. Web.