Lockheed Martin Control Arm Redesign

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Abstract

Our group was tasked with redesign a Lockheed Martin product component in a way that made it stronger, or cheaper through a change in design and made through additive manufacturing. The part we chose to redesign was the control arm for Lockheed Martin's Amphibious Combat Vehicle (ACV). Our team's redesigned control arm is not only cheaper to manufacturer, but also stronger than the current Lockheed version. The crossbeam design on our version of the control arm shaves away tons of material that previous version required making the component stronger, lighter, and a cheaper version of the current Lockheed Martin AVC control arm.

Keywords

Control Arm, Additive Manufacturing, Amphibious Combat Vehicle, Lockheed Martin, Suspension

Introduction

Our Redesigned control arm was a product of a task given to our design team by Lockheed Martin as a part of our engineering design project. Lockheed gave our team several options to choose from all with their own tasks, and challenges. However, each did share one general theme, which was redesigning some part or component to not only make it better but also use additive manufacturing to do so. Our group decided to take on the option that allowed us to pick any part and redesign it in a way that made it stronger, or cheaper through design and additive manufacturing. The part we chose to redesign was the control arm for Lockheed Martin's Amphibious Combat Vehicle (ACV). The control arm is responsible for connecting the wheel to the suspension, enabling a smooth ride for the vehicle passengers**.** This is a crucial part to the ACV, and through additive manufacturing and redesigning models for the control arm our group attempted to create a stronger, cheaper part version of the Lockheed Martin component in this project.

Literature Review

Land combat vehicles such as the Lockheed Martin Amphibious Combat Vehicle (ACV) need strong structures to support its solid and heavy body. In addition to that, it needs durable compartments in order to withstand various impact during battle and non-battle performances. Control arm is one of the crucial compartment in the vehicle. The control arm of the ACV needs to be strong,durable and anti-corrosive all at once. Various patents worldwide have helped our research and investigation on finding and designing the perfect materials and design for the control arm.

The first patent is 'Suspension System for Vehicle' invented by Unkoo Lee from Hyundai Mobils Co Ltd [1]. In summary, this invention reduce the shock from the impact between wheels and the vehicle body that may occur during assorted performances. Particularly, this invention able to tolerate with a minute vibration by producing a displacement of the buffer larger than the displacement of a wheel. It enhances riding comfort by a buffer that absorbs the shock given by the impact and vibrations. This innovation and patent has specifically helped us to understand the importance of having a control arm that could withstand shock and massive vibrations in compliance with riding comfortness. Besides that, the ability for control arm to cope with shock and strong vibrations is also important as this will ensure the reliability of control arm having long-term performances. Furthermore, this invention emphasizes that control arm is the vital part in suspension system. In order to maintain a smoother ride for the ACV which obviously the vehicle will go through rough terrain most of the time, it is important for the control arm to be able to hold off strong vibrations.

Next, the second patent that contributes idea for us to design the control arm is by Lloyd D Masser, called 'Suspension for Automotive Vehicles'[2]. This whole suspension system was innovated by the inventor so as to be the main bridge that connects the spring with the body of the vehicles and also the wheel. It is stated from the patent that the control arms are connected to many other parts in the suspension system such as the axle, the rubber brushed pivot, axles pivots, torque rod and the joints. All of these compartments are pivotally secured to the brackets so that the control arm could swing vertically. This patent has a very clear picture and figure of how control arm should be assembled in the suspension system of vehicles. It has contributed to

the idea of designing the correct and right shapes and dimensions for specific type of vehicles. Coordination of the control arm within the suspension system has to be taken into account as well. This patent specifically taught us on how to understand the basic principle of coordination of control arm in suspension system for vehicles. A control arm that is attached to the body of the vehicle and the wheel should not be fixed at one place as it might cause huge shock towards the vehicle itself and will eventually lead to the wearing out of the control arm.

In conclusion, two of the patents stated above have contributed to many great founding of our basis designing process. Not just that, these patents have led us to a better understanding of what control arm really is and how it should works in the suspension system.

Design Process

We began our design process by first identifying a product that we could redesign using additive manufacturing. This product needed to fulfill two requirements - it needed to be suitable for additive manufacturing, and it needed to be currently utilized by Lockheed Martin. After researching existing solutions and patents, we decided to redesign the control arm of LM's 8x8 Amphibious Combat Vehicle (ACV), an 8-wheel drive vehicle designed to transport troops on land and in water.

The next step of the design process was to determine which aspects of the control arm could be remodeled for cheaper and more effective use. We determined that we would strive to increase the strength and sturdiness of the arm while minimizing the amount of material needed to create the product.

To begin, we observed the shape and structure of the current control arm model, which is a solid beam with rounded ends and holes that enable the attachment of the piston. We implemented the laws of physics to brainstorm various structures that could still support the same amount of horizontal and vertical force as the current control arm used by Lockheed Martin. We had several different options - we could alter the solidness of the object, the shape, or do a combination of both. We ultimately decided to alter both by making the content hollow and by changing the overall shape.

The structure of our redesigned control arm needed to be constructed so that it would require less material but have equal strength. To do this, we had many structural options, including cross beams, vertical beams, horizontal beams, or lattice beams. The determination of which formation would be most appropriate was based off of our knowledge along with research on the law of statics. The law of statics is implemented in the construction of bridge trusses, in which the cross beams allow for the tension and compression forces to cancel each other out.

The finalization of our product involved deciding what material the new control arm would be constructed from. There were various materials that were considered, including concrete, plastic and numerous metals. Each came its own benefits, for example, concrete would provide us with the maximum durability, while metals would be cheaper and more easily produced. We decided to utilize an aluminum alloy to reduce the overall weight of the product and resist corrosion. Aluminum alloys are alloys that are predominantly made of aluminum, along with other elements, such as copper, silicon, magnesium and zinc. The percent composition of each element depends on the type of alloy.

The alloys we investigated for the control arm consisted of eight different options, each typically used for different applications. The alloys considered were Alloy 1100, Alloy 2011, Alloy 2024, Alloy 3003, Alloy 5052, Alloy 6061, Alloy 6063 and Alloy 7075 [3]. To determine which was most suitable for the creation of the control arm, we compared each alloy by their performance in various aspects - formability, weldability, machining, corrosion resistance, heat treating and strength.

	Formability or Workability	Weldability	Machining	Corrosion Resistance	Heat Treating	Strength	Typical Applications
Alloy 1100	Excellent	Excellent	Good	Excellent	No	Low	Metal Spinning
Alloy 2011	Good	Poor	Excellent	Poor	Yes	High	General Machining
Alloy 2024	Good	Poor	Fair	Poor	Yes	High	Aerospace Application
Alloy 3003	Excellent	Excellent	Good	Good	No	Medium	Chemical Equipment
Alloy 5052	Good	Good	Fair	Excellent	No	Medium	Marine Applications
Alloy 6061	Good	Good	Good	Excellent	Yes	Medium	Structural Applications
Alloy 6063	Good	Good	Fair	Good	Yes	Medium	Architectural Applications
Alloy 7075	Poor	Poor	Fair	Average	Yes	High	Aerospace Applications

Based off our knowledge of the Amphibious Combat Vehicle and its purpose, we prioritized corrosion resistance and strength, due to the fact that the vehicle will transcend underwater and could easily lead to rust if the wrong alloy were to be utilized. Strength was also significant because the control arm would be supporting the vertical force exerted by the weight of the truck along with the horizontal forces that result from the sides being pulled. Alloy 2024, Alloy 3003 and Alloy 5052 were immediately eliminated due to poor performance in either of those categories.

After further analysis of considerably important aspects, such as formability and machinability, the selection was then narrowed down to Alloy 6061 and Alloy 7075. Both demonstrated decent, if not exceptional capabilities in every single category, the difference being that Alloy 6061 demonstrated "excellent" corrosion resistance while Alloy 7075 exhibited high strength. The ultimate decision was made after we decided that corrosion resistance was of slightly more importance than strength.

Design Results

Our final redesigned product had a variety of changes. The original Lockheed Martin Amphibious Combat Vehicle utilized a control arm that was a solid piece of metal with drilled areas for bolts to connect it to parts of the suspension and part of the wheel. The arm is made like other control arms for various vehicles, built from steel and not additively manufactured. The changes we made to the control arm were making it lighter, stronger, less expensive, and rust resistant.

The first major change we made was to make the Amphibious Combat Vehicle control arm lighter than the arm currently being used. In order to do this, we cut spaces out of the solid part and designed the arm to hold stress like a truss bridge. This significantly reduced the amount of material used throughout the part. The decreased amount of material used in the part would save money and manufacturing time in the future if the part were to be utilized on a large scale. The part would also be lighter than steel by our decision to use aluminum alloy 6061 instead of solid steel. Steel is extremely heavy and would wear on the vehicle axle and suspension more

than aluminum alloy, as aluminum alloy is extremely light. The conversion to use of aluminum would be better for the control arm for a variety of reasons.

The second change that we made to the control arm was making it stronger. The solid nature of the part currently being used can definitely withstand large forces, but we believe that the use of trusses would allow the part to withstand larger forces. The trusses used throughout the control arm would work just like a truss bridge. The laws of statics and the tension and compression forces acting on the horizontal beams of the control arm would greatly reduce the forces acting on the arm, itself.

The use of aluminum alloy 6061 would greatly increase the rust resistance of the control arm used in the current design. It is rated as having an excellent resistance to rust and oxidation. Aluminum is much more rust resistant than steel, which is a type of iron and oxidizes easily.

Conclusion

Through our work as team from start to finish for the duration of this project our team came up with a redesigned version of Lockheed Martin's A.V.C control arm that was better that the original. Brainstorming as a group allowed us to bounce ideas off of one another when initially designing the component. This design was furthered by the continued brainstorming along with researching of different materials along with reviewing patents. Our team's redesigned control arm is not only cheaper to manufacturer, but also stronger than the current Lockheed version. The new crossbeam design on our version of the control arm shaves away tons of material that previous version required making the component lighter while also making it stronger. This new design paired with additive manufacturing that reduces the waste associated with subtractive manufacturing also reduce the material necessary for the piece making it a stronger, lighter, and cheaper version of the current Lockheed Martin AVC control arm.

References

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