

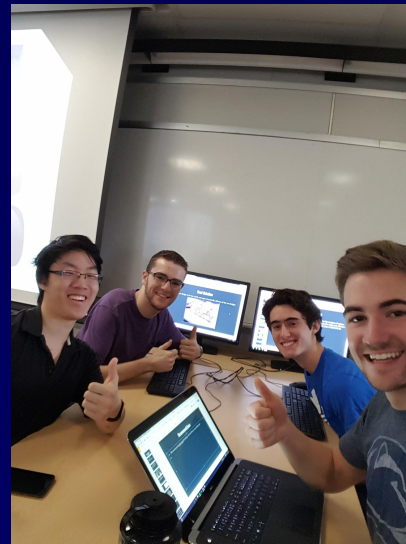
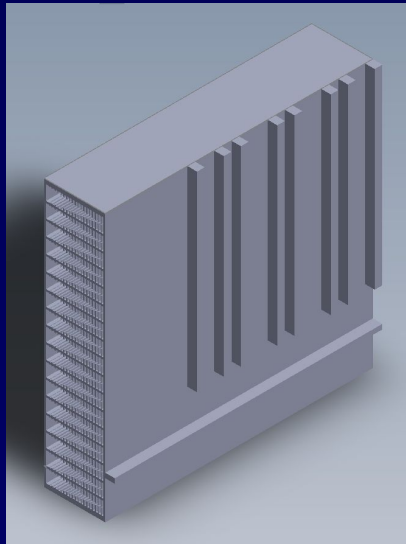
Lockheed Martin

Additive Manufacturing

Introduction to Engineering Design EDGSN 100 Section 002

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Presented to: Prof. Berezniak

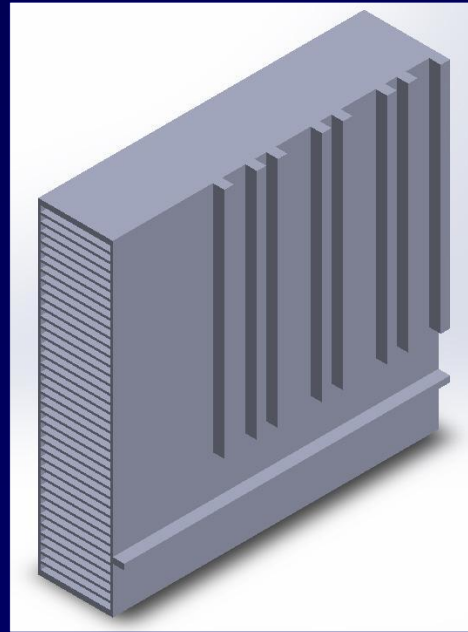
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Purpose

- Lay out the process that was used to develop a design to modify a heat exchanger for additive manufacturing for Lockheed Martin.
- Lay out the background studies of heat transfer that led to the development of the initial ideas as well as the final results of these studies leading to the final design.

Background

The objective of this project was to design a more efficient forced air heat exchanger for electronic components based upon a partially designed solidworks file provided by Lockheed Martin.



Sponsor



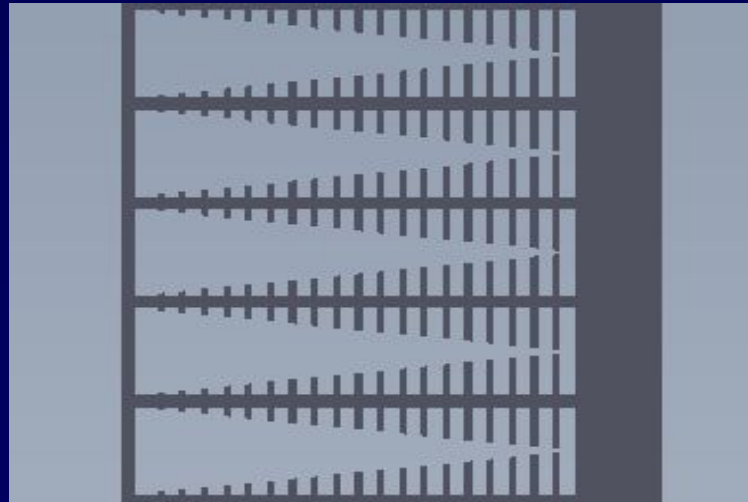
- Lockheed Martin is a global security and aerospace company with Headquarters in Bethesda, Maryland
- Most recently they purchased Sikorsky, another large aircraft manufacturer
- 126,000 employees worldwide
- They are principally engaged in the research, design, development, manufacture, integration and sustainment of advanced technology systems, products, and services

Project Description

- Lockheed Martin provided five options for the project: a heat exchanger, a sensitive payload shock absorber, connector backshells, a USB hub mounting bracket, or a redesign of another Lockheed Martin product that could be improved with additive manufacturing.
- The heat exchanger project was selected because it is the best fit and most practical for additive manufacturing applications.
- The purpose of this project is to redesign a traditionally manufactured air-flow through heat exchanger for additive manufacturing (AM). Redesigning an exchanger for additive would decrease the lead time from multiple months to several weeks.

Procedures (1 of 2)

- Initially, the preliminary design was inspected for design flaws.
- Then, many different types of modifications were applied and evaluated for efficacy and practicality, in which the best modifications were selected.
- Next, the modifications were applied to the model to improve the efficiency.



final modified design sample

Procedures (2 of 2)

- Further, various materials were analyzed according to:
 - Cost
 - Performance
 - Density
 - Corrosion
 - Practicality for additive manufacturing

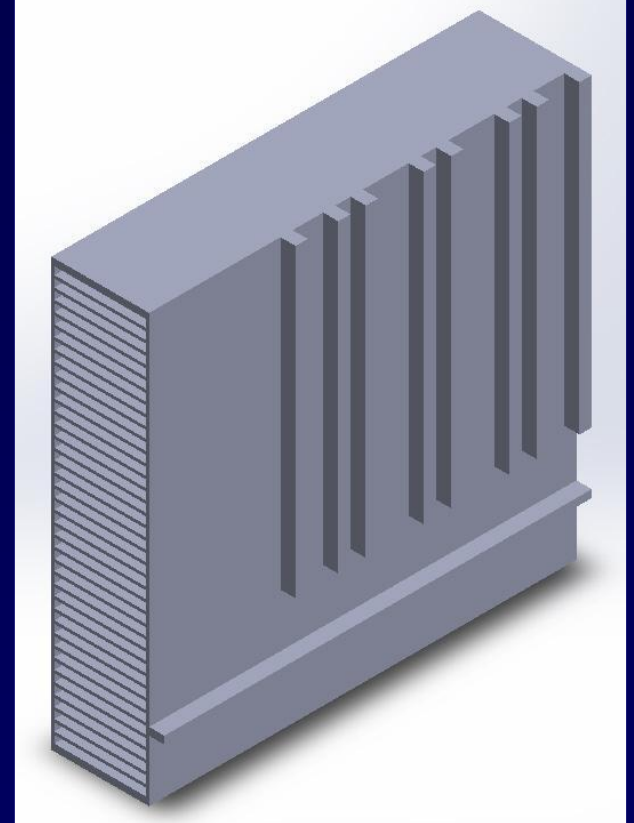
| Material | Thermal Conductivity (W/mK) | Heat capacity (J/cm ³ K) |
|-------------------|-----------------------------|-------------------------------------|
| Silver | 428 | 2.50 |
| Copper | 390 | 3.43 |
| Aluminium | 236 | 2.55 |
| Stainless steel | 24 | 3.93 |
| Alumina | 25 | 2.71 |
| Beryllia | 250 | approx. 3 |
| Aluminium nitride | 170 | approx. 3 |

Commodity price sensitivities

| | 2015 Base | 2016 Base | 2017 Base | Stress Case |
|-----------------------------------|-----------|-----------|-----------|-------------|
| Gold (\$/oz) | \$1,150 | \$1,150 | \$1,150 | \$1,000 |
| High quality met coal (\$/tonne) | \$100 | \$95 | \$105 | \$80 |
| Newcastle thermal coal (\$/tonne) | \$62 | \$60 | \$60 | \$55 |
| Aluminum (\$/lb) | \$0.75 | \$0.75 | \$0.80 | \$0.65 |
| Copper (\$/lb) | \$2.50 | \$2.35 | \$2.60 | \$2.20 |
| Nickel (\$/lb) | \$5.25 | \$4.80 | \$5.25 | \$4.40 |
| Iron ore 62% Fe China (\$/tonne) | \$50 | \$45 | \$45 | \$40 |
| Zinc (\$/lb) | \$0.85 | \$0.80 | \$0.90 | \$0.75 |

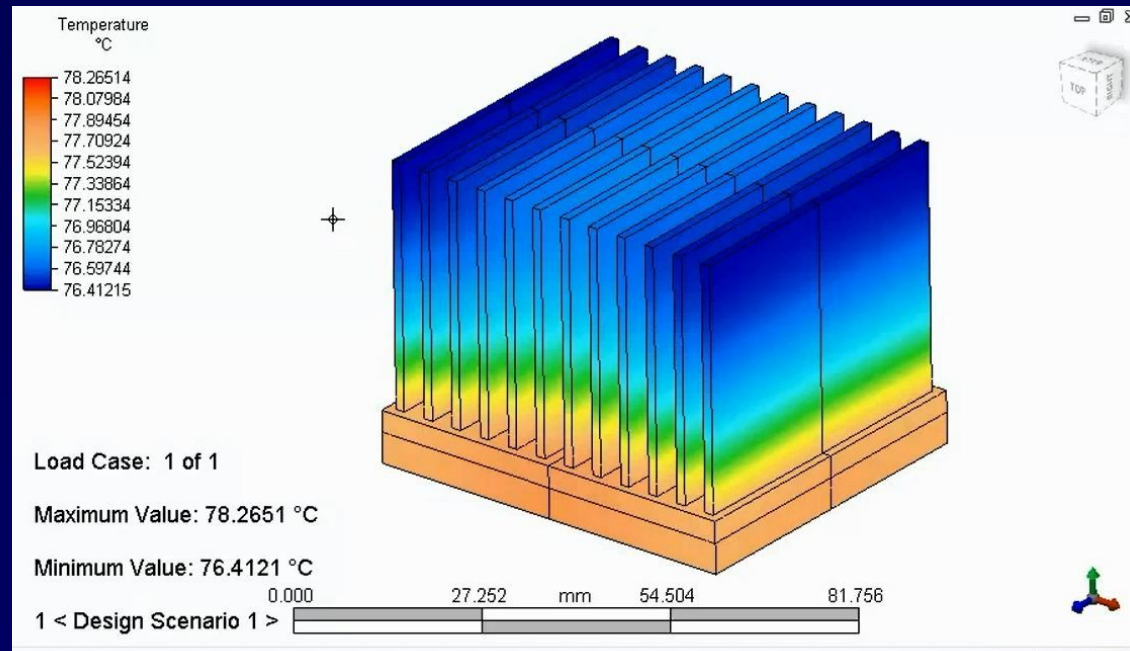
Results and Discussion

- The heat exchanger shall be made out of aluminum due to the fact that it was significantly more cost effective than silver and copper, although it has a lower heat capacity and thermal conductivity.
- It was most efficient to add fins, assuming a forced air application, because increased surface area improves the ability to dissipate heat under natural convection as well as forced convection applications.
- The fins in the preliminary design did not allow heat to dissipate effectively through convection.



Conclusions and Recommendations

-Develop an aluminum prototype of the heat exchanger to perform a heat flow and cost analysis to compare with heat exchangers of similar materials.



Sample heat flow analysis of a heat sink.

Closing

Special thanks to:

Professor Berezniak - Project facilitator

Lockheed Martin - Corporate sponsor

The design project was a great opportunity to explore skills and interests in the field of engineering while learning to collaborate with a group of people toward achieving a common goal.