Heat Exchanger Design Project

EDSGN 100/ Section 010/ Team 6/ Professor Xinli Wu

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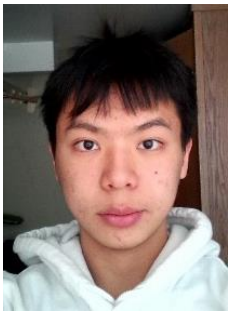

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Abstract: (Josh)

In Introductory to engineering design, students were separated into groups and given a real world problem to solve for their final design project. The groups consisted of four to five underclassmen students who have had little experience in the engineering industry. Students were required to use their previous knowledge and acquired research to develop a new and improved design for a Lockeed Martin product. Groups had the choice between five different projects that could be improved in terms of additive manufacturing. The majority of groups chose a design project that appealed to their interests.

Introduction: (Josh)

Lockeed Martin has had countless problems with manufacturing computer heat exchangers efficiently and inexpensively. The computer heat exchanger peaked the interest of many teams due to its unique structure and function. The members of our team used basic concepts learned in introductory engineering courses including calculus and physics to relate to this specific design project. Within the company requirements, groups sought to change the material and internal geometry of the modern heat exchanger.

Problem Statement: (Josh)

The method in which computer heat exchangers are produced is expensive, time-consuming therefore inefficient. In one sense, the majority of heat exchangers are made with copper which is thermal conductive but it is expensive and difficult to manipulate. Another type of metal or alloy would help the function and cost of the exchanger. Since the outside couldn't be changed, the internal geometry had to be modified in order to improve the heat transfer.

Mission Statement: (Josh)

Within the instructed specifications, the intent is to change the material and internal geometry in order to decrease the cost and build time of heat exchangers. Specifically, the design should increase of the overall surface area of heat exchanger. The volume should stay the same and the process of manufacturing should be improved through the use of additive manufacturing.

Project Management: (Josh)

Design Project 2

Computer Heat Exchanger			DURATION (days)
START DATE	END DATE	DESCRIPTION	
3/21/16	3/28/16	Target Specifications	7
3/28/16	4/4/16	Gathering Information	6
4/4/16	4/6/16	Brianstorming	2
4/6/16	4/11/16	Design Matrix	5
4/11/16	4/13/16	Design Drawings	2
4/13/16	4/18/16	Prototype Construction	5
4/18/16	4/20/16	Design Evaluation	2
4/20/16	4/24/16	Testing and Project Report	4
4/24/16	4/25/16	Oral Presentation	1

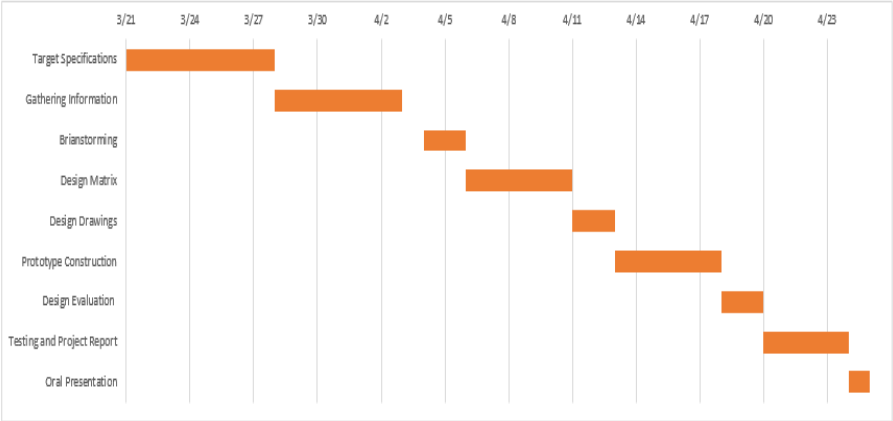

Table 1: Gantt chart

Design Specifications: (Krishna)

The task was to redesign an existing heat exchanger for Additive manufacturing. These heat exchangers have to be made a proper material and an ideal AM process has to be followed. The price of the design and the time it takes to build the design have to be taken into account. While sample parts can be built using a plastic technology, any differences in design between plastic built part and actual part should be reported. The design must strictly follow CCA mating criteria's and the overall size must remain the same. While the internal geometry through which the heat flows can be altered the overall surface area must remain the same as the sample model.

Concept Generation: (Wilson)

Concept 1

Open one side of the heat exchanger to increase the surface area in order to improve the air flows through the machine. (The air flows weren't steady)

Concept 2

Use Copper alloy (C11000) as our materials and have wave-shape plate as the internal geometry instead plate of a linear in the heat exchanger (It is a little expensive and heavy)

Concept 3

Attach silicon heat pads at the outer shell of the heat exchanger in order transfer the heat in the heat exchanger more efficiently (price is too high and not improving the efficiency that much)

Concept 4

Use honey-combs as the internal geometry in order increase the surface area so that it makes the heat exchanger perform better. (It is

hard to build and the heat did flow out well as we expected)

Concept 5*

Use Aluminum alloy (6101) as our material and have wave-shape plate as the internal geometry with little spikes at the surface of it to increase the efficiency of the heat exchanger. (It works well and this not only improve the efficiency but also decrease the overall price, so this would be the best design feature)

Problem/Opportunity: (Krishna)

The current process of producing a heat exchanger is expensive, because the most common material used to produce a heat exchanger is copper. Another major problem with manufacturing the heat exchangers is that it is time consuming and cumbersome. The design being made up of aluminum instead of the traditional copper is much cheaper and still efficient. The design takes only a few minutes to manufacture opposed to hours taken to manufacture a normal heat exchanger, by incorporating the waves the design's surface area increased by 20 percent making it more efficient. The design is not only cost effective, it is also easy to manufacture.

Design Matrices: (Krishna)

Selection criteria	Design A	Design B	Design C	Design D
Ease of handling	3	4	3	2
Ease of manufacture	3	3	3	3
Durability	4	3	2	4
Thermal conductivity	2	3	3	4
Cost of manufacture	4	2	3	3
Portability	4	1	1	4
Size	3	3	3	3
Complexity	1	2	3	2
Efficiency	2	3	1	4
Sum	26	24	22	29
Rank	2	3	4	***1

Table 2: Decision Matrix of Material

Selection criteria	Jagged Edges/A	Jagged edges/B	Extended Spirals/C	Wavy Pattern/D
Ease of handling	4	3	4	3
Ease of manufacture	2	4	2	2
Durability	3	3	3	3
Thermal conductivity	3	2	2	4
Cost of manufacture	3	1	2	2
Portability	4	2	2	3
Size	3	2	4	4
Complexity	2	3	2	3
Efficiency	1	4	1	3
Sum	25	24	22	27
Rank	2	3	4	1

Table 3: Decision Matrix of Internal Geometry

Description of Final Design: (Josh)

The final product included the original design with modifications to the material and internal geometry. The internal geometry included a wavy pattern that could be described by a sine function. The pockets enabled air to be captured and cooled quickly. The wavy pattern had vertical rods throughout the entire inside which was able to disperse the heat more efficiently. Aluminum was the selected material because it had great durability, thermal conductivity, and heat expansion. It was cheaper than any other composite or metal which made it the frontrunner for our choice.

Solid Modeling Drawings: (Zhenda)

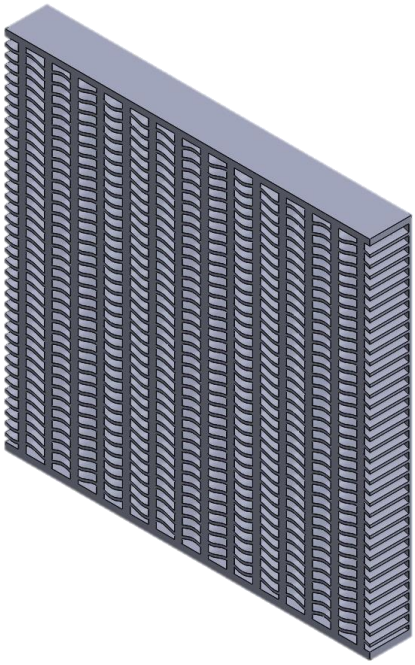

Figure 1: Isometric section view of final design

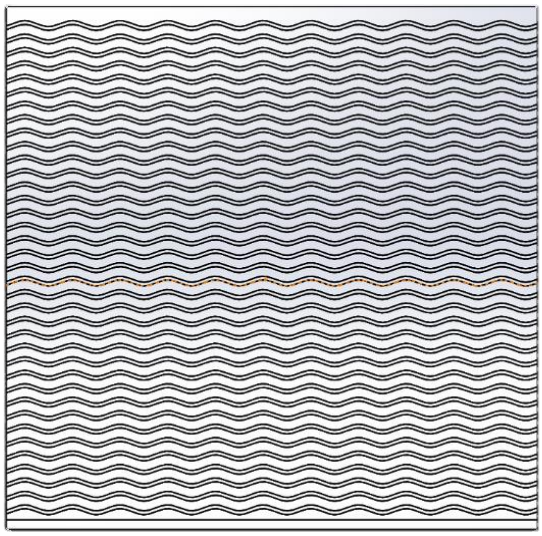

Figure 2: Front section view of final design

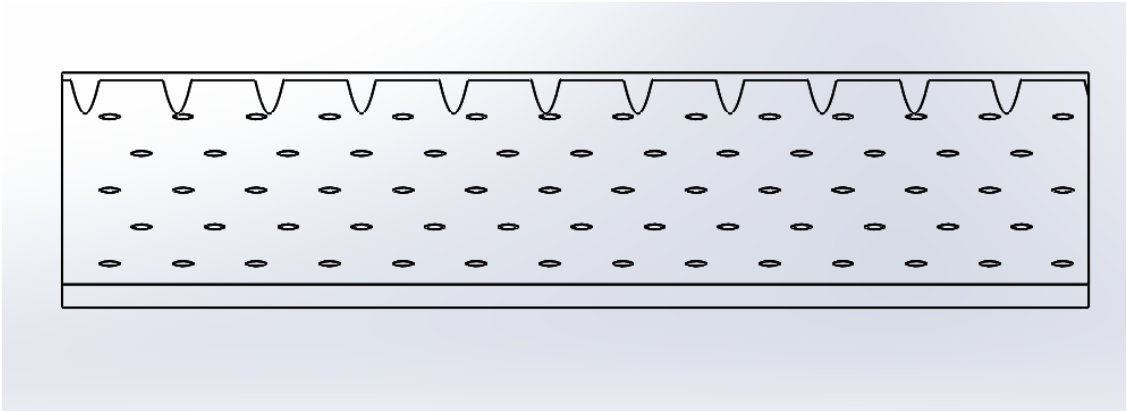

Figure 3: Top section view of final design

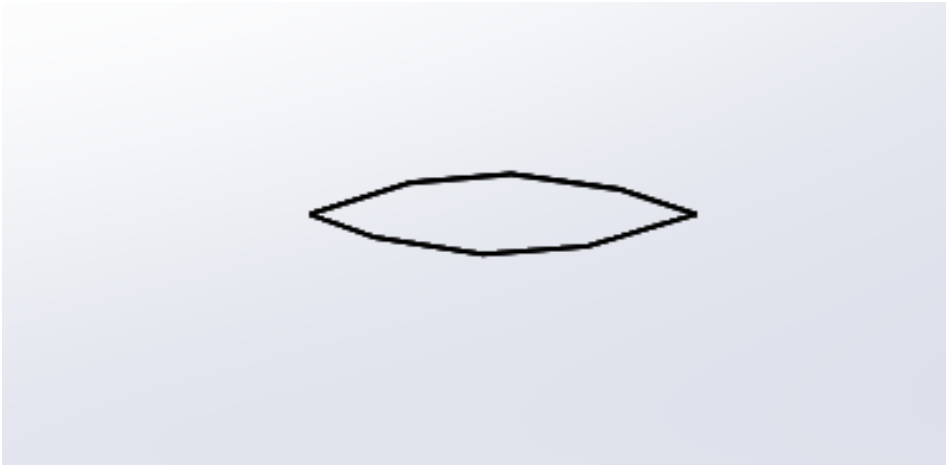

Figure 4: Top section view of an individual rod

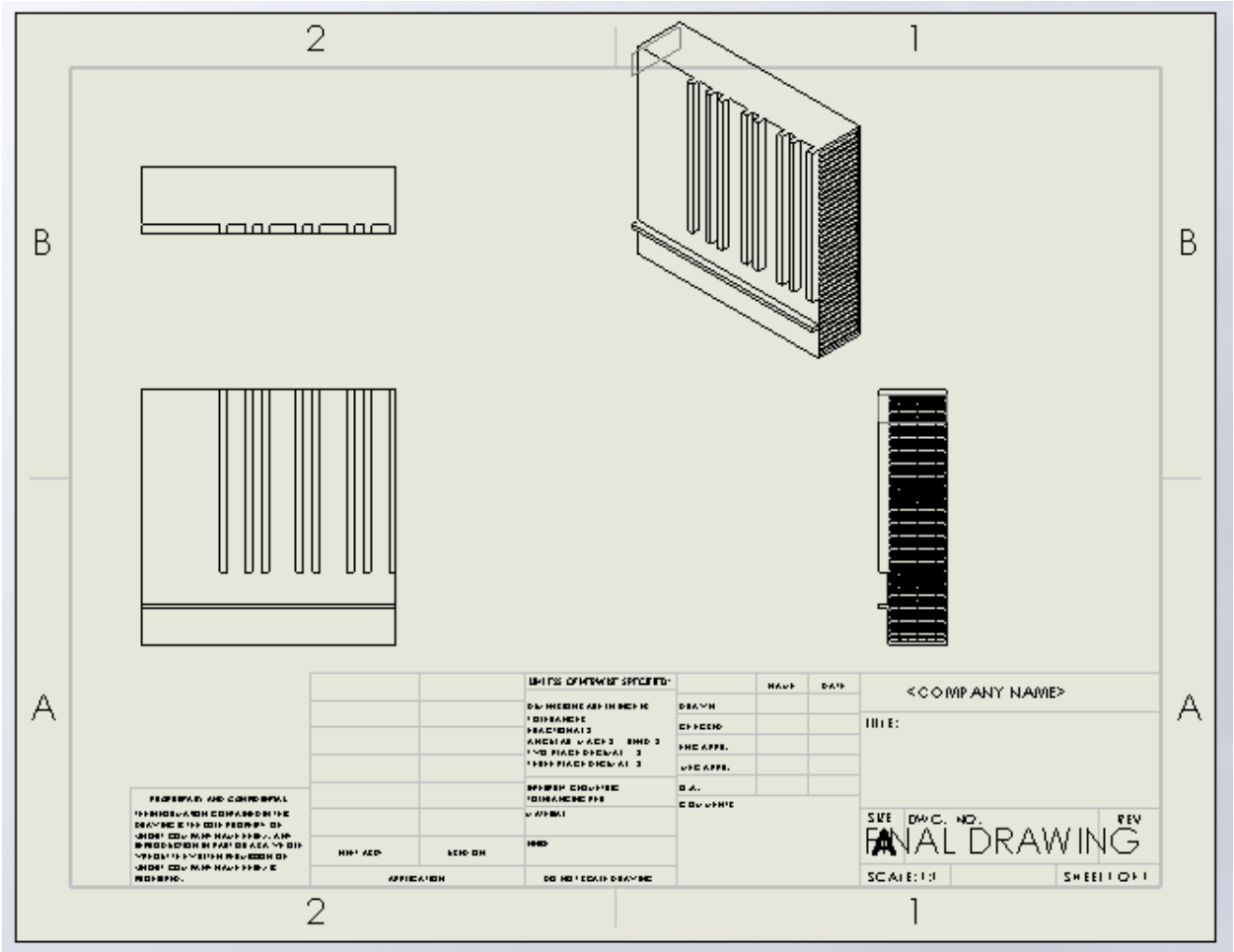

Figure 5: Multi-view drawing of final design

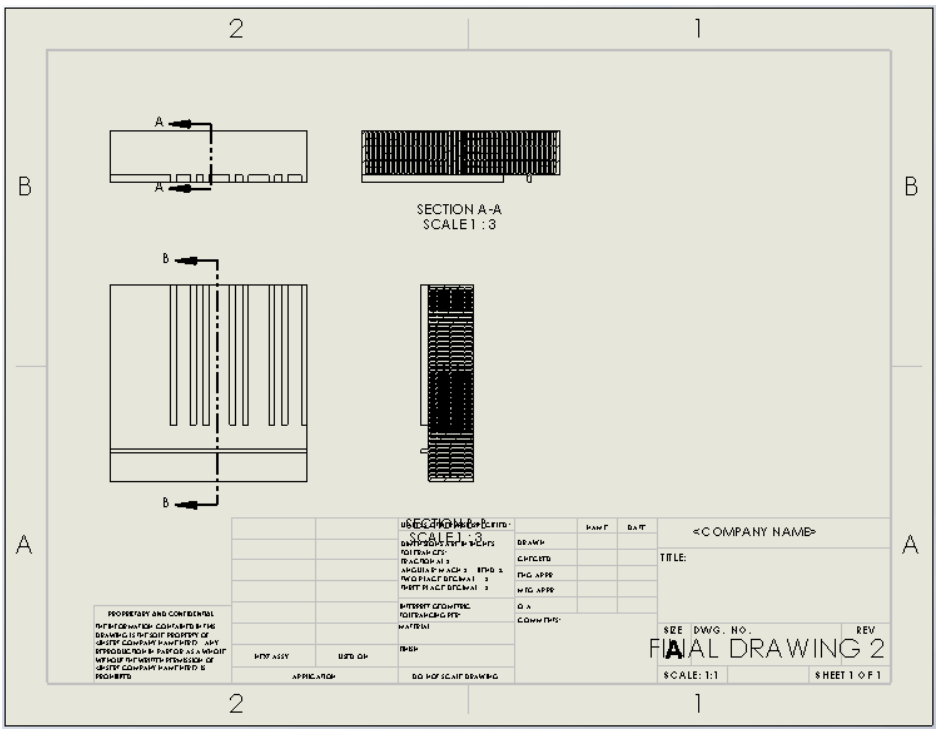

Figure 6: Front and top section views of final design

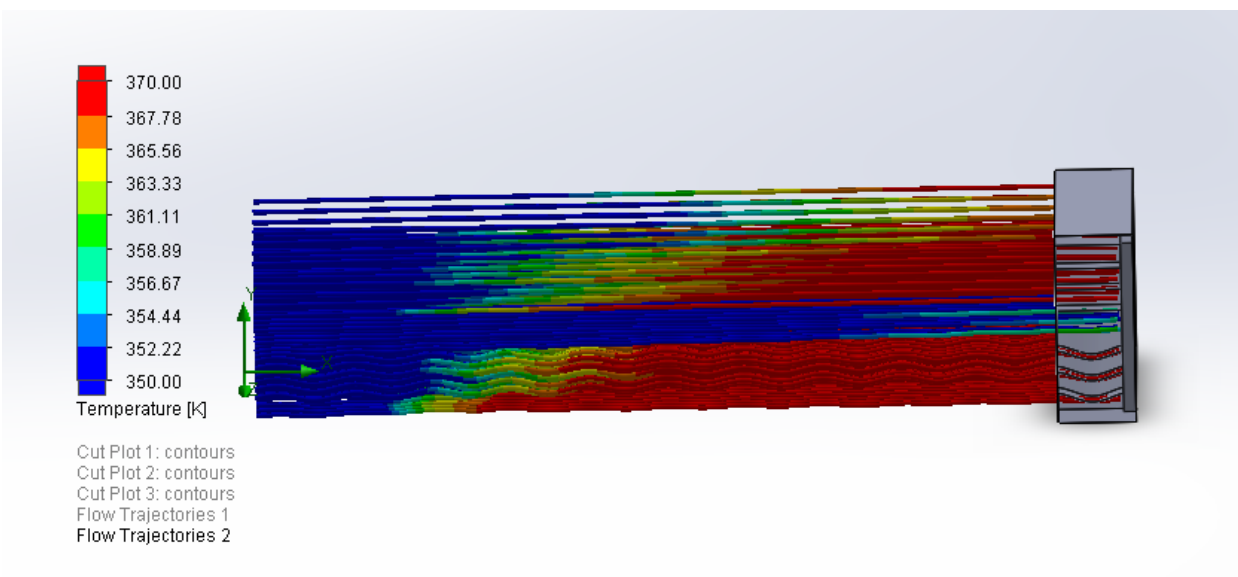

Figure 7: Heat simulation comparison between the original and final design

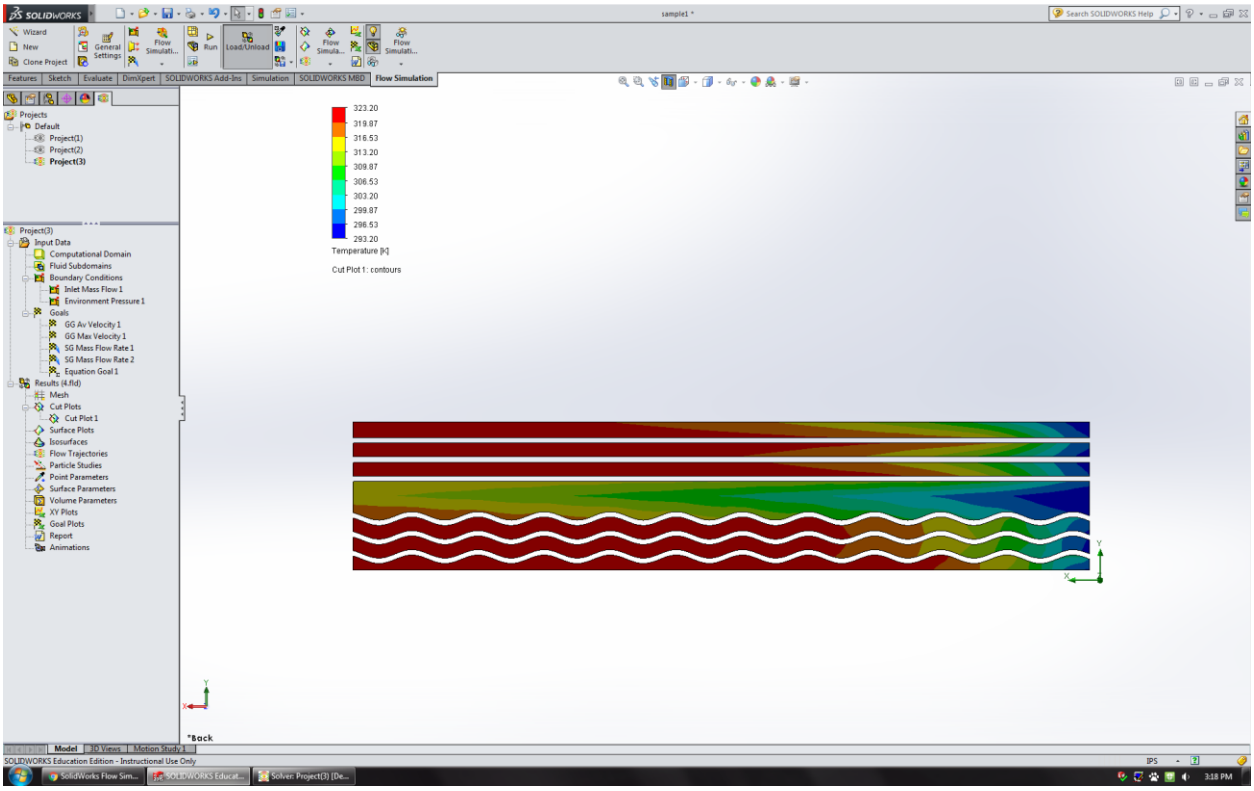

Figure 8: Heat simulation of final design

Prototype: (Zhenda)

Figure 9: Isometric view of prototype

Figure 10: View of section cut and full view

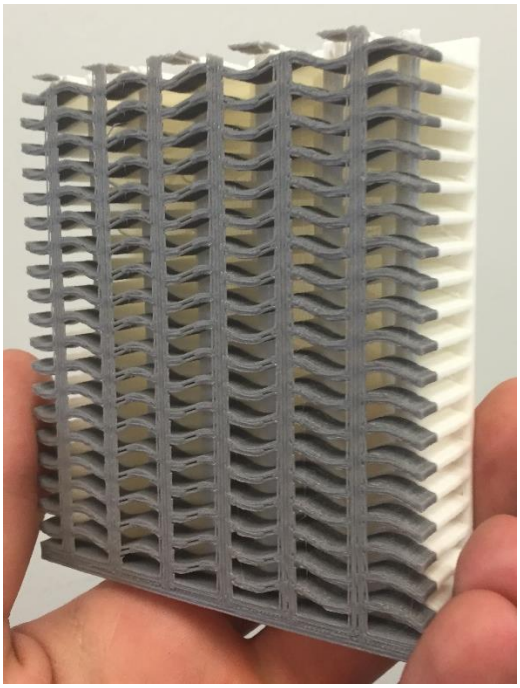

Figure 11: Section view of full scale design

Design Features: (Wilson)

The design uses the waves instead of the standard lines thereby improving the efficiency of heat flow. The design uses the spines to control air turbulence. The design is made up of aluminum making it very cost effective, also the density of aluminum is almost three times lesser than copper making the design buoyant. In conclusion, the design is very efficient, extremely light and has a greater internal surface area, the design is really innovative because of the spines it uses to control air turbulence. The design is very advantageous and easy to manufacture.

Assessment: (Wilson)

The new version of the heat exchanger is good because it is built by aluminum alloy which not only increased the heat conductivity but also made the overall design lighter and cheaper. In addition, in order the improved the performance of the efficiency, the design for the internal geometry was made in a wave-shape with little spikes attached at surface of the wave plate which make the new design increase its efficiency about 20% greater than the original design.

Conclusions: (Wilson)

Developing a new version of the heat exchanger was challenging at the first place, because the task is to make the heat exchanger to increase its efficiency and decrease the build time and cost. However, after our team did a huge amount of analysis and researches for the heat exchanger, the task became much easier as it break down the project in to two major parts – the internal geometry and the properties of the heat exchanger. In the end, the new design was accomplished in three weeks and the overall efficiency increased about 20% higher than the original design.

References: (Wilson)

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Presentation:

Attachment in table of contents

Brochure:

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