Christian Tello

MEGN 471: Heat Transfer
SolidWorks #1: Silicon Chip + Fins
Prof. Rickey | 2/28/2020

Problem Statement:

An aluminum heat sink is attached to a 30W Silicon chip. The temperatures and velocities of air flowing over the chips will be calculated using Case A with a convection heat transfer tip condition, this will calculated for the various fin arrays (1x1), (3x3), (6x6), (9x9), and (12x12) on top of the base. This calculation will then be compared against the SolidWorks flow simulation.

Assumptions:

Constants

P_chip = 30; [W] Power of the Chip
h_avg = 125; [W/m^2/K] Average Convection Coefficient
k_fin = 200; [W/m^2/K] Conduction Coeffiecient
T_amb = 20; [K]
L_chip = 0.025; [m]
L_fin = 0.015; [m]
D_fin = 0.002; [m]
L_c = L_fin + D_fin/4;

Calculated Constants

n = [1 9 36 81 144];
P = pi*D_fin; %[m] Perimeter
A_c = P*L_fin + pi*(D_fin^2)/4;
m = sqrt(h_avg*P/(k_fin*A_c)); %[m^-1]

Part 24:

The number of fins had the greatest impact on the global maximum and minimum values that were calculated (temperature and velocity). The maximum temperature recorded was ~288 ℃ when the (1x1) fin array was used, and ~78 ℃ when the (9x9) fin array was used. Thus, the more fins, the better the heat dispersed from the chip, up until the point wherein the fins are too closely arranged. This is due to the fact that when the air flows over the fins it creates turbulence and thus pockets of very fast air as well as pockets of very slow air are made. If the fins are arranged at (12x12) there’s more turbulence within the fin array and begins to make the heat dispersion worse.

25:

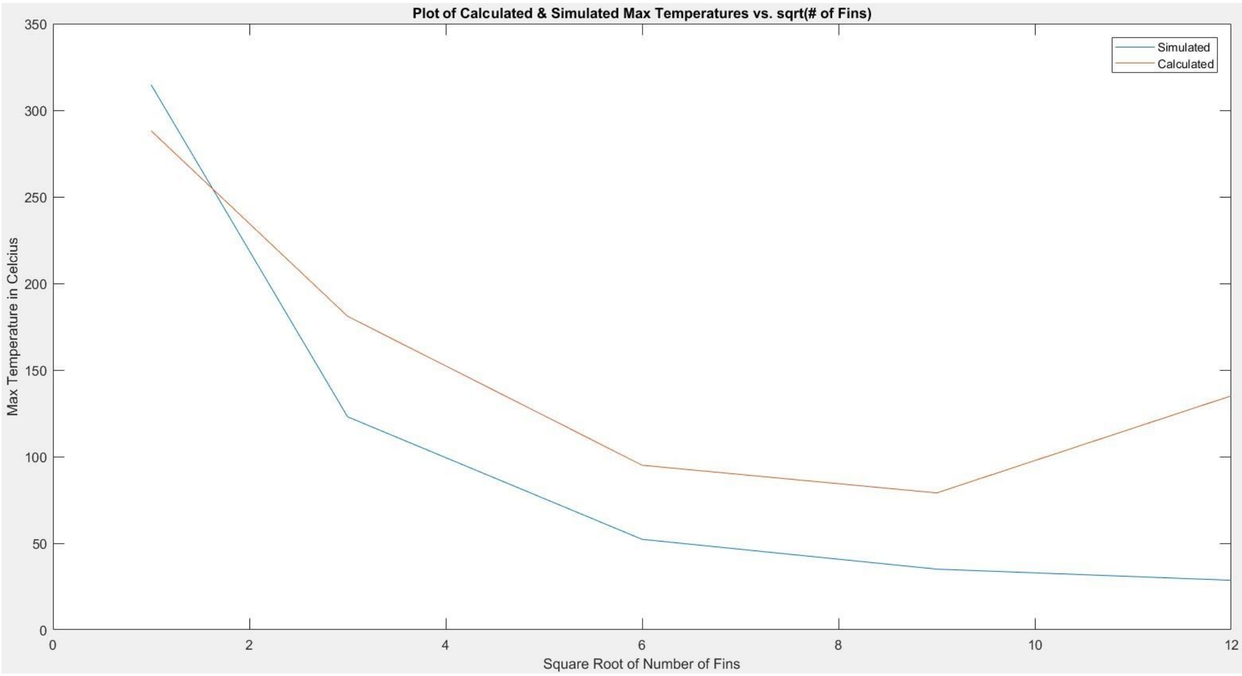

Figure 1. Plot of Calculated and Simulated Temp. vs sqrt(# of fins)

The plots begin to diverge once the fins reach a critical number of fins, and the simulated results predict a lower value (except in the 1x1 array), while the calculations seem to be more on the conservative side of predicting the maximum temperatures which makes sense from an engineering perspective.

26:

The heat transfer calculation doesn't take into consideration the stagnation of the air between the fins in the arrays, this means that the convection coefficient decreases as more fins are placed in the same area. The 9x9 array performed the best, and the 6x6 array performs better than the 12x12 array.

27:

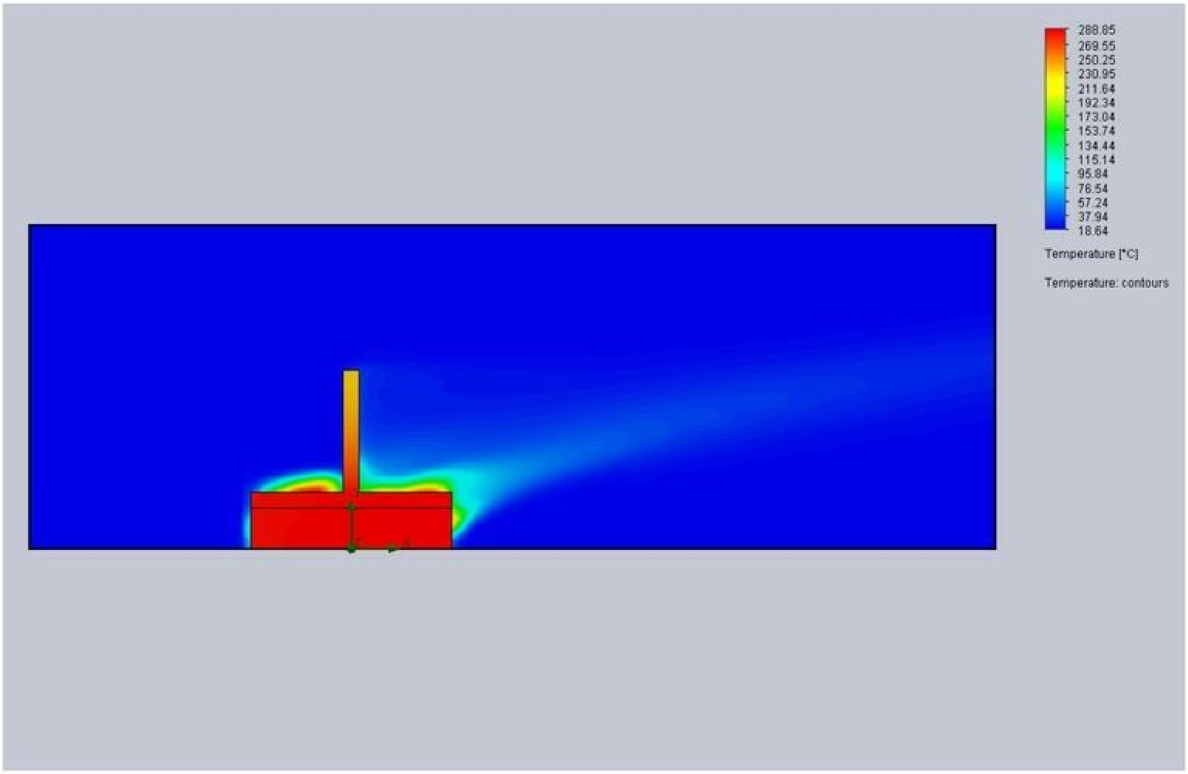

Figure 2: Temperature Cut Plot for 1x1 Fin Array

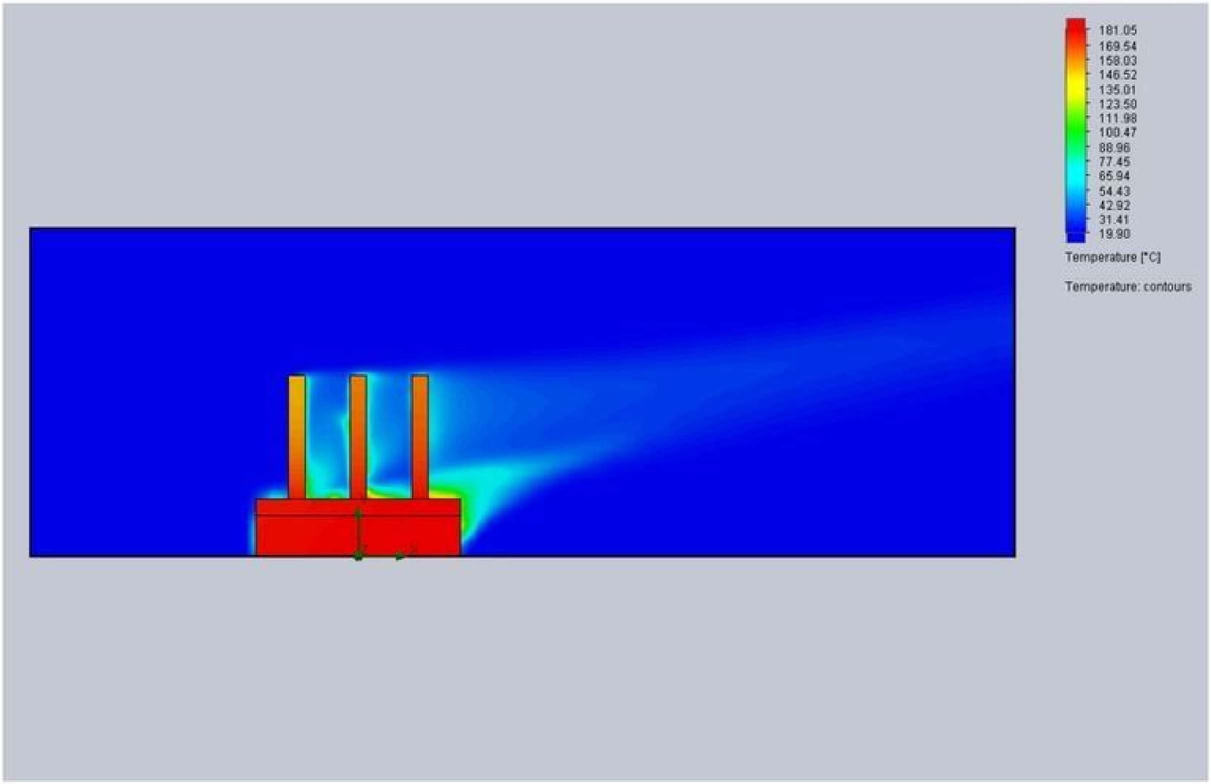

Figure 3: Temperature Cut Plot for 3x3 Fin Array

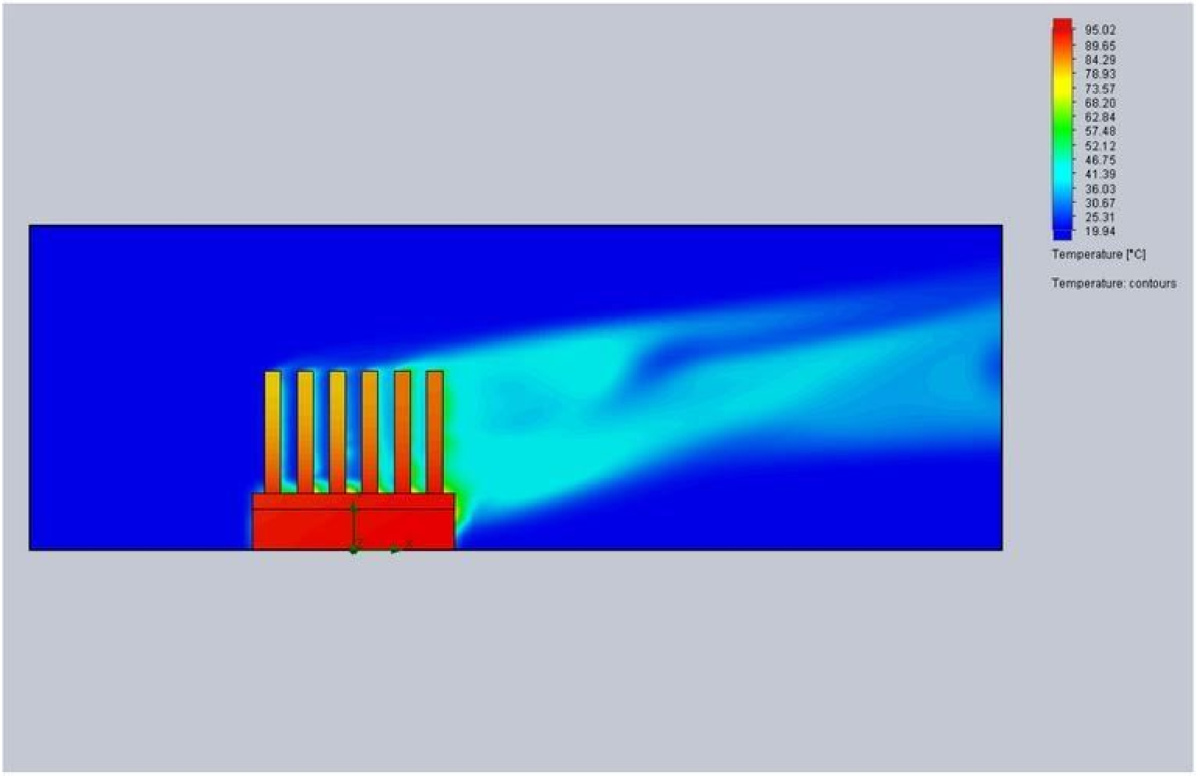

Figure 4: Temperature Cut Plot for 6x6 Fin Array

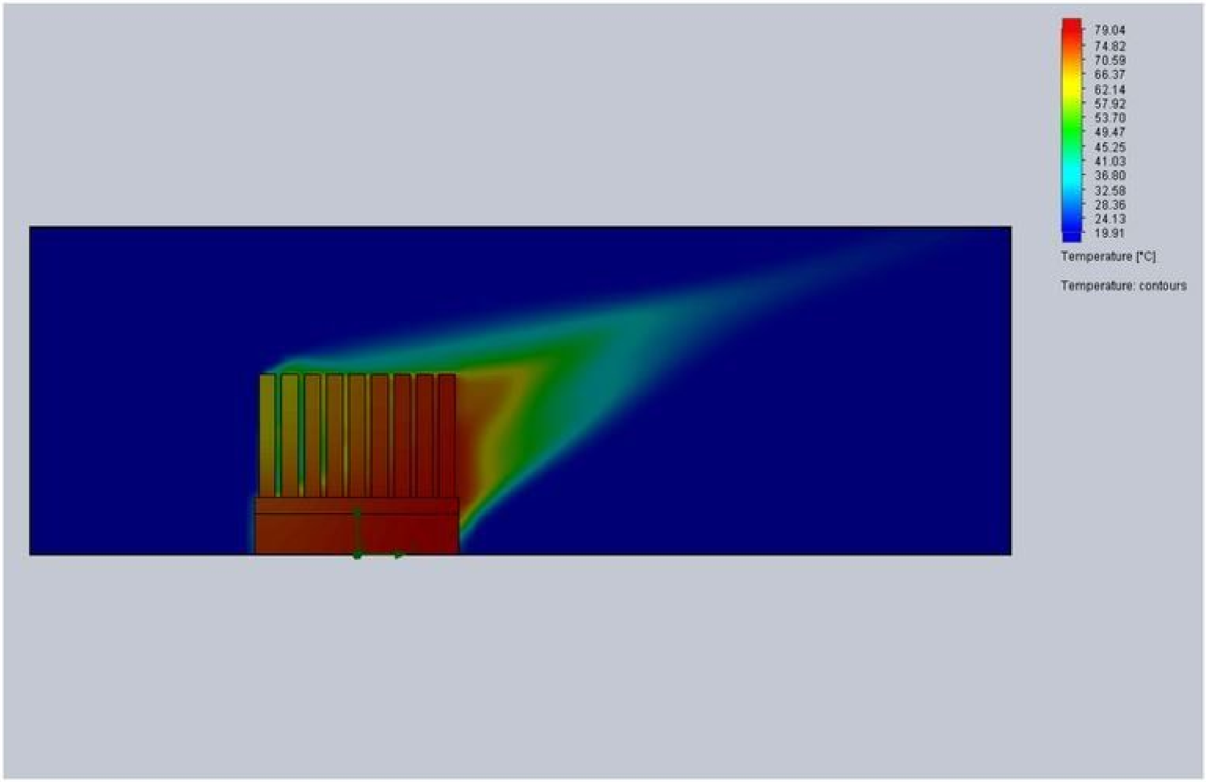

Figure 5: Temperature Cut Plot for 9x9 Fin Array

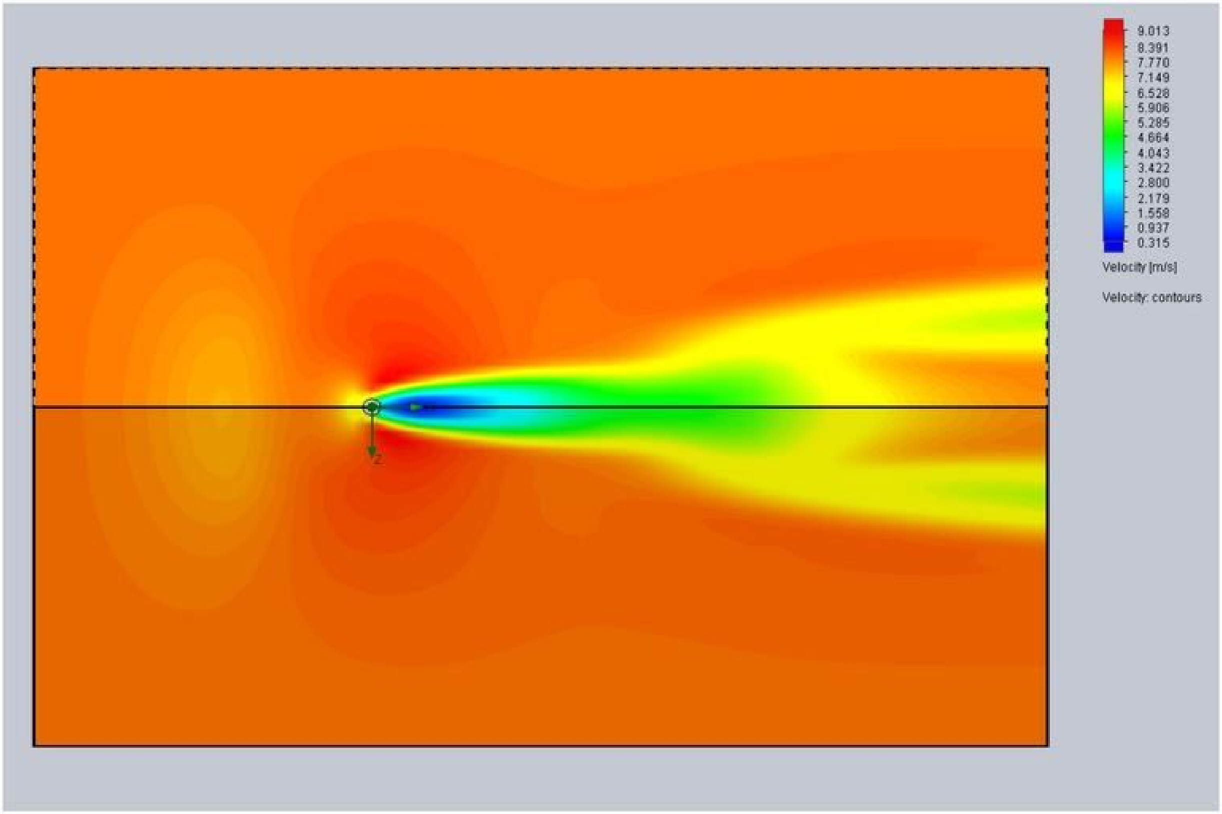

Figure 6: Velocity Cut Plot for 1x1 Fin Array

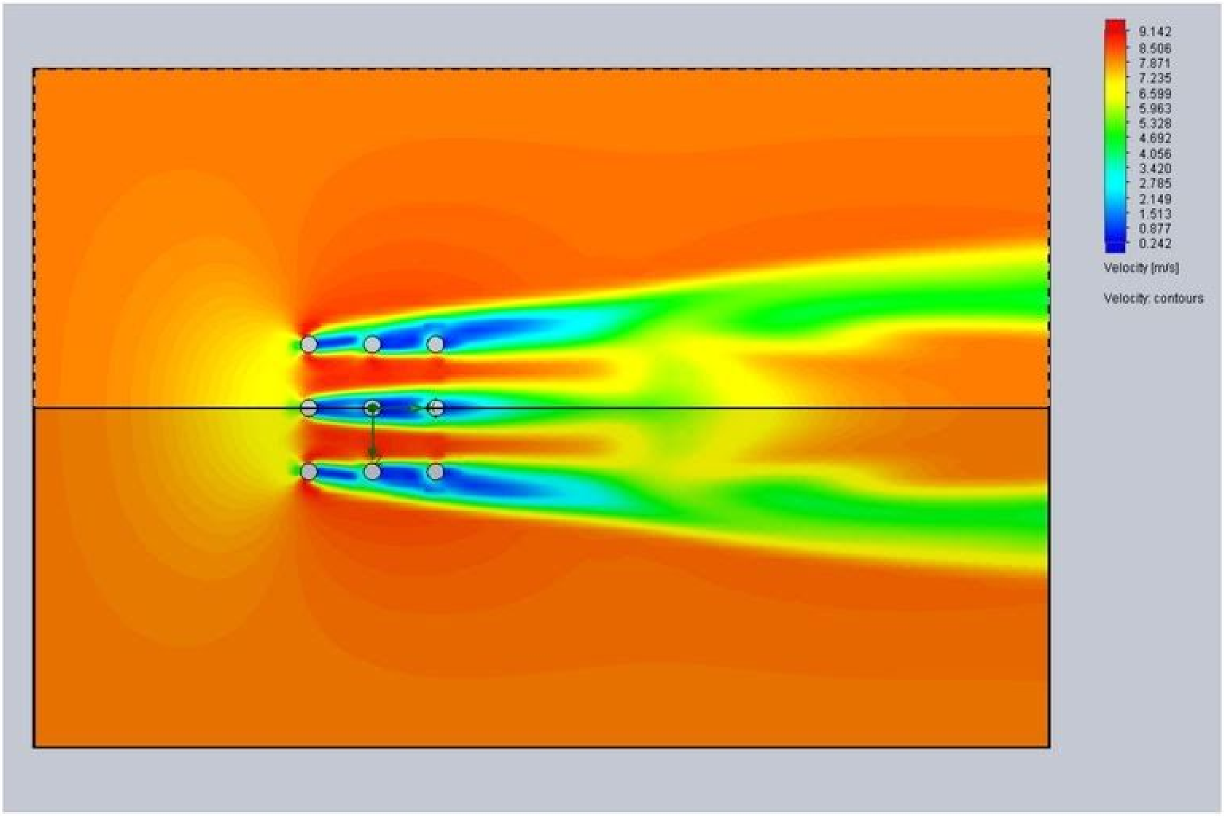

Figure 7: Velocity Cut Plot for 3x3 Fin Array

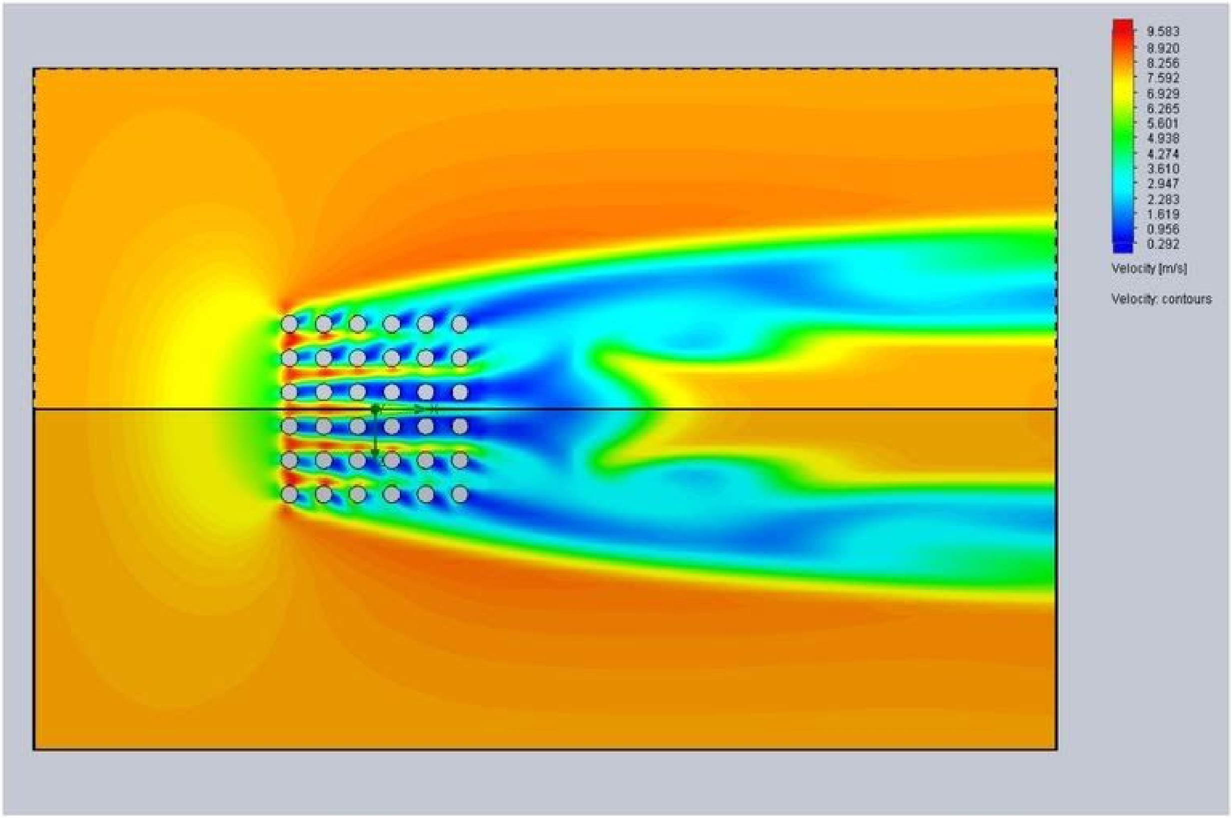

Figure 8: Velocity Cut Plot for 6x6 Fin Array

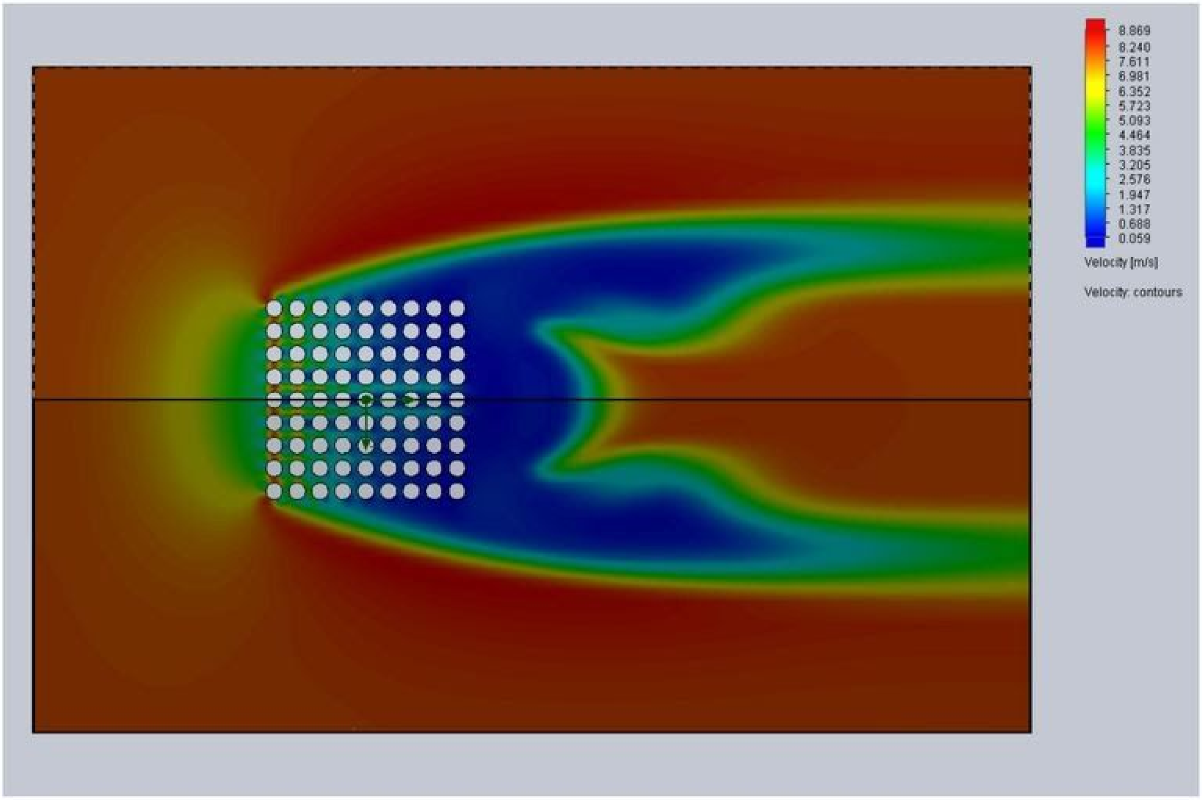

Figure 9: Velocity Cut Plot for 9x9 Fin Array