HEAT TRANSFER ANALYSIS ON LAPTOP COOLING SYSTEM BEFORE AND AFTER INTRODUCING A COOLER AT EXHAUST

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Abstract - *This project uses CATIA and SolidWorks tools to do a thermal analysis and cooling system optimisation of a laptop microprocessor. The aim of the study is to evaluate the ability of the heat pipe, heat sink, and VGA fan to dissipate heat under various operating conditions. The laptop's complex solid model was created using the CATIA software, whereas the SolidWorks software was put to use for the thermal analysis. The results show that the cooling system can effectively dissipate heat produced by the microprocessor, and that the thermal performance is affected by elements like airflow rate and thermal conductivity of the materials used in the heat sink. After the result of these studies, a new cooler is developed and fitted to the previous system in order to further improve thermal efficiency, or the capacity to dissipate heat. This minute change has a significant impact on the laptop's ability to dissipate heat. This research will be helpful in the design and development of new cooling systems for electronic devices which are similar to laptops.*

Key Words: Cooling, Cooling System, Thermal Analysis, Simulation, Heat Dissipation.

1. INTRODUCTION

Overheating is a major problem with laptop operation because it can negatively impact stability and performance, possibly resulting in hardware failure and system crashes. The aim of this research was to examine the thermal behaviour of a laptop computer and evaluate how well the suggested cooling technique succeeded in preventing overheating issues. In this project, we thermally analysed the HP Pavilion i5 11 Generation laptop. where we concentrated on researching the cooling system's capacity to dissipate heat under diverse operating conditions. To accomplish this, we created a solid model of the laptop using CATIA software, and then conducted the thermal analysis using SolidWork software. Although the i5 11 Generation Intel Core processor is extremely efficient, it produces a lot of heat. In order to avoid thermal throttling, which may decrease efficiency and affect the processor, this heat must be adequately drained. Therefore, an effective cooling system should be built in place to maximise thermal efficiency. To reduce the heat that the CPU produces Heat pipe, heat sink, and VGA fan were already included in the model, but we added a new cooler to the design to maximise heat dissipation.

1.1 Relevance

Since it addresses the crucial problem of thermal management in laptops, the thermal analysis of a laptop cooling system is a very relevant and important task. Laptops frequently struggle to adequately dissipate heat because of the growing need for high-performing computing and thin designs. Through research and performance optimisation, the cooling system's efficiency will be improved, resulting in better thermal control and overall laptop reliability.

This project will help to our understanding of laptop thermal behaviour by doing a thermal analysis under various operating conditions and workload situations. It will involve analysing heat dissipation systems including VGA fans, heat sinks, and heat pipes and exploring potential design modifications or improvements. The project's findings can be used to design laptop cooling systems that are more effective and reliable, improving user experience, extending hardware lifespan, and minimising the possibility of thermal failures.

The primary objectives of this project is to improve user experience, reliability, energy efficiency, and environmental impact while also enhancing laptop performance. The project aims to resolve these problems and contribute to the development of more effective, reliable, and environmentally friendly laptop cooling systems by addressing thermal management concerns.

2. LITERATURE SURVEY

In paper titled "CFD Thermal Analysis on Laptop Cooling System Using Loop Heat Pipe Technology", Mr. Ravikiran Chinthalapudi shows that Science and technology have begun a new era in the history of humanity. As a result of technology progress, electronic devices have become smaller, lighter and faster, especially laptops. Laptops are subjected to a lot of heat for high process units, which cause high spots on the processing unit. Because the current cooling system is weak for heat dissipation in warm locations, the trendy MLHP heat pipe technology is upgraded for better cooling. Compared with current active cooling technologies, this novel passive cooling solution also provides various benefits such noise-free operation, lower energy usage and increased reliability. This article offers a visual depiction of a new laptop cooling solution and evaluates Fluent's approach for the victimization of fluid dynamics. This test has varying thermal reductions, 30W, 32W, 43W under various operating situations, such as regular laptop usage, normal usage, while battery charge and 100% mainframe load are heavily charged. Heat dissipation and dispersion under different operating situations were explored. Claves: Laptop, LOOP, CFD

Mr. Syamsuri, etal. explained in the paper "Laptop cooling numerical simulation using Computational Fluid Dynamics" that laptop's cooling solution is very important. In some cases, due to poor cooling an over heat on the mother board, main chip, and other components occurs, so that the laptop is quickly broken. Therefore, it is necessary to know the temperature distribution so that over heat can be overcome. One of the methods to determine the temperature distribution in this final project is a flow simulation, using CFD (Computational Fluid Dynamics), 3D method with the variation if different air flow velocity, i.e., 5 m/s, 10 m/s, and 15 m/s. The higher the air flow rate, the higher the cooling occurs. From the temperature contours it is shown that the hot temperature is built up on the back of the heat sink. The results of the validation of this study and previous studies obtained an error that occurred was around 4%.

Mr. N.H. Ranchagoda studied in the paper "Implementation of an External Intelligent Cooling System for Laptops using TECS" Laptop coolers are external devices, which are ancillaries to the existing cooling mechanism of laptops, in order to reduce their internal temperature. Available coolers do not provide efficient cooling in high ambient temperatures. This paper presents the implementation of an intelligent laptop cooler, which can vary its performance according to the laptop temperature and ambient temperature, and actively cool the air flow by using thermoelectric coolers (TECs). In this work, a dynamic air flow is intelligently cooled by the device and the process will be controlled, based on the feedback provided by a temperature sensor placed at exhaust vent of laptop. Further, the device is designed to reduce dust content in the air flow which passes through the laptop, ultimately an effective cooling is provided to the laptop through this device while increasing the lifetime of the laptop.

Mr. Channamallikarjun explained in the paper entitled "Thermal analysis of CPU with variable baseplate heat sink using CFD" that the computational fluid dynamics is concentrated on the forced air cooling of the CPU using a heat sink. This paper utilizes CFD to identify a cooling solution for a desktop computer, which uses an 80 W CPU maximum whereas this number will be increased in the range of 70-120W in the forthcoming desktop computer systems. This paper considers the optimal plate fin heat sink design and cylindrical fin heat sink design with variable copper base plate and the control of CPU heat sink processes. To have a better heat dispersion performance, a computational fluid dynamic is utilized to search for an optimal set of plate-fin. Base plate thickness, fin thickness, fin profile and fin material parameters are to be handled together due to the frequently encountered space limitations. The different heat sink designs are analysed by using commercial CFD software packages ANSYS design modeler for modelling and ANSYS meshing for CFD meshing and finally ANSYS fluent is used for CFD solver. The well converged; results are compared with the experimental data. Especially, replacing aluminium with copper as base plate material improved the performance. This study will benefit the design engineers involved in electronic cooling and also help to reduce the significant increases in the sound power emitted by the CPU.

3. Problem Definition

Thermal throttling, a feature that slows down the processor's speed to prevent overheating, is usually triggered in laptops when there is an excessive buildup of heat. This has a negative impact on performance and compromises the user experience, especially when performing complex activities like gaming, editing videos, or using resource-intensive software. The reliability and durability of laptop components can be significantly impacted by continuous exposure to high temperatures. The ageing process can be accelerated by overheating, which also raises the danger of thermal failures and necessitates costly repairs or early replacement of crucial hardware parts like the CPU or GPU.

Insufficient cooling can make laptops feel warm to the touch and radiate heat into the user's lap or through the keyboard, making them uncomfortable to use for a longer period of time. In addition, when cooling systems have trouble adequately dissipating heat, fans may need to run at higher speeds, which results in excessive noise that can be annoying and intrusive.

4. Preprocessing

4.1. 3D Model Creation

Using the CATIA V5 software, a thorough 3D model of the HP laptop was created. This model was detailed and included all necessary parts, including the chassis, heat sinks, fans, and vents. This 3D model is exported from CATIA V5 to Solidworks software for thermal analysis.

Fig -1: Actual Model

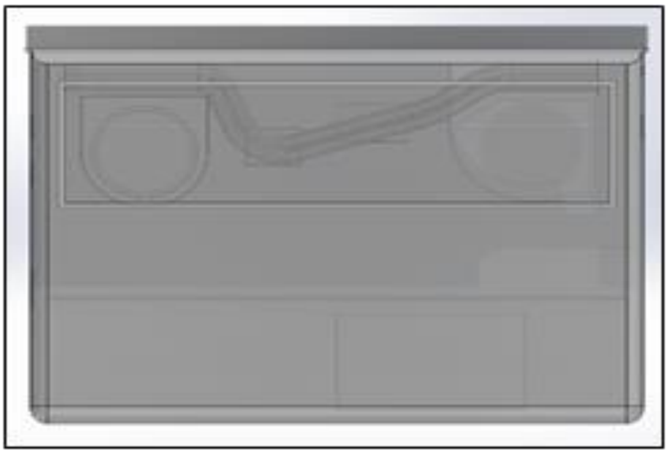

Fig -2: 3D Model

4.2 Mesh Generation

Using the SolidWorks Simulation meshing tools, the mesh generation settings are defined. The model was then analysed by software, which then generated the mesh depending on the given parameters.

Studied the created mesh for accuracy and quality. The mesh visualisation tools in SolidWorks are used to study element distortion, evaluate element quality, and evaluate the mesh's overall appropriateness for thermal analysis. Some required modifications are then made to the mesh controls or geometry to enhance the mesh quality.

Table -1: Cell counts

Total Cell count:	333263
Fluid Cells:	186969
Solid Cells:	146294
Partial Cells:	91558
Trimmed Cells:	30

4.3 Boundary Conditions

In thermal analysis, boundary conditions are significant because they define the thermal interactions between the system being studied and its surroundings. To precisely simulate heat transfer and temperature distribution, you can create a variety of boundary conditions in SolidWorks for thermal analysis.

The appropriate boundary conditions for the CFD simulation are defined here. This involves describing any other relevant boundary conditions, such as heat sources inside the laptop, as well as the intake and output conditions, including temperature, velocity, and pressure.

Thermodynamic parameters	Static Pressure: 1.01 bar Temperature: 20.05 °C
Velocity parameters	Velocity vector Velocity in X direction: 0 m/s Velocity in Y direction: 0 m/s Velocity in Z direction: 0 m/s
Solid parameters	Default material: Aluminum 6061 Initial solid temperature: 20.05 °C
Turbulence parameters	Turbulence intensity and length Intensity: 2.00 % Length: 2.300e-04 m

Table -2: Boundary Condition

4.4 Cooler Design

Based on the analysis results, identified areas of improvement in the laptop cooling system. Developed a new cooler design, considering factors such as size, shape, fin arrangement, fan specifications, and material selection. Utilized CATIA V5 software to create a detailed 3D model of the new cooler design.

- Three fans installed inside the casing of specifications.
- 9232-12M
- Path: Fans Pre-Defined\Axial\JMC Products
- Fan Type: Axial
- Rotor speed: 314.159 rad/s
- Outer diameter: 0.092 m
- Hub diameter: 0.051 m
- Direction of rotation: Counter – clockwise

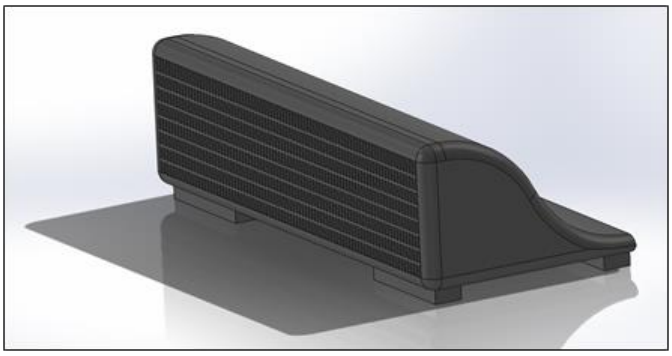

Fig -3: Design of Cooler

4.5 Simulation, Analysis and Visualization

Based on the specified parameters and boundary conditions, SolidWorks solves the governing equations of heat transport during the analysis run using numerical methods. The temperature distribution and other thermal parameters inside the model are calculated and updated iteratively by the software until convergence is attained. Convergence indicates that the problem has stabilised and that additional iterations have little to no impact on the outcome.

SolidWorks gives users access to the results after the analysis run is finished so they may further analyse and visualise them to learn more about the thermal behaviour of the design. Then, in order to assess the performance and come to wise design judgements, we looked at temperature distributions, heat fluxes, thermal gradients, and other relevant characteristics.

5. Results

5.1 Before Applying Cooler

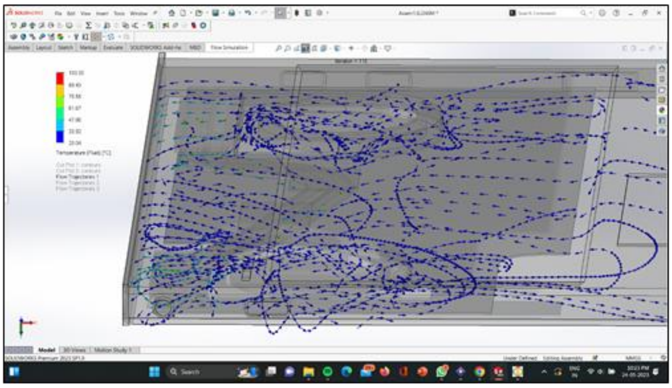

Fig -4: Fluid flow before applying cooler

The above fig. shows the temperature of fluid flow in the laptop. We can observe that the temperature of the air before passing through the fins is near 20 degrees but after passing through the fins it becomes around 40-60 degrees Celsius. This means that around 10-15 degrees Celsius of heat is getting dissipated through the fin due to the air flow.

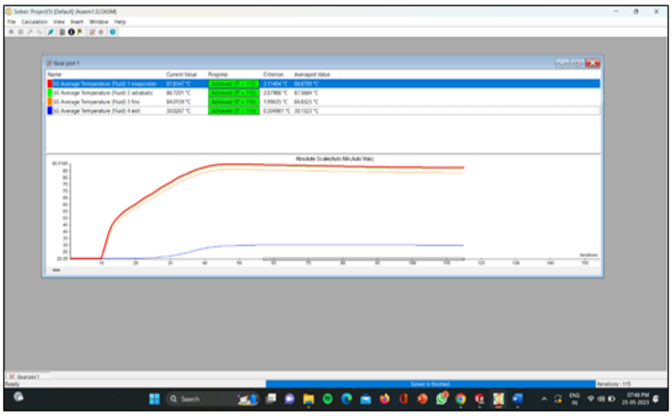

Fig -5: Results before applying cooler

The above fig. shows the temperatures of different sections of the laptop. We can observe that after a certain time, the temperature of the processor chip remains constant at 87 degrees Celsius. The temperature of the air is increased from 20 degrees Celsius to 30 degrees Celsius which means 10 degrees of heat is getting dissipated due to air.

5.2 After Applying Cooler

The figure shows the temperature of fluid flow after applying the cooler. We can observe that heat is getting dissipated due to the extra flow rate provided by the cooler.

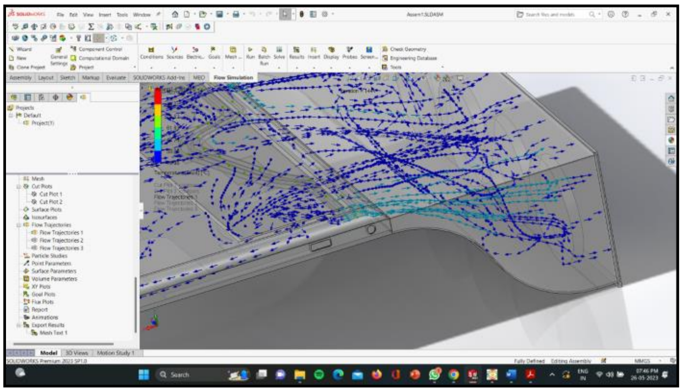

Fig -6: Fluid flow after applying cooler

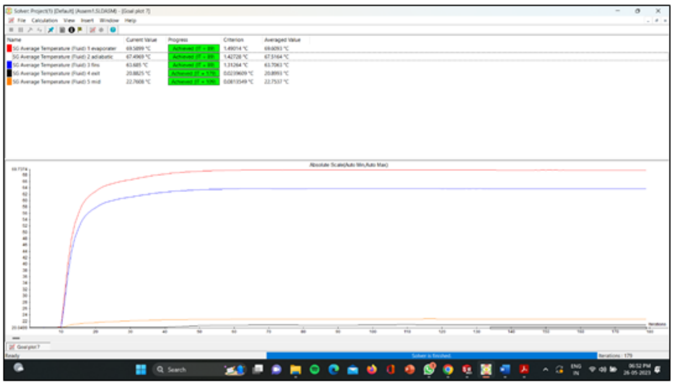

Fig -7: Results after applying cooler

The above figure shows different temperatures at different sections after the application of the cooler. We can observe that the temperature of the processor chip got reduced from 89 degrees Celsius to 69 degree Celsius, Reducing the temperature of about 20 degrees.

6. Conclusion

Improvements in temperature control and heat dissipation have resulted from an analysis of the cooling system and the creation of a new cooler for the HP laptop. The laptop's temperature was lowered by 10 degrees by the existing cooling system's optimisation prior to the application of the new cooler. However, a further temperature drop of 20 degrees was achieved once the new cooler was installed.

The results clearly show how the new cooler design improved the laptop's cooling capabilities. Innovative design elements of the cooler, such as its size, shape, fin configuration, fan specs, and material choice, have improved airflow and boosted heat dissipation. The cooler has significantly reduced the risk of overheating by effectively spreading heat, which has improved the overall performance of the laptop and increased the lifespan of its components.

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