Modelling and Simulation of Air Vents for Material Saving with Improved System Performance

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Abstract: ***The manufacturing sector consumes one-third of global energy and produces material waste. The waste reduction without affecting the system performance is a serious issue for the manufacturing of complex functional parts. The additive manufacturing technology could enable the fabrication of functional intricate parts with negligible waste. Fused deposition modelling (FDM) technology is one of the most widely used advanced digital manufacturing method due to its ability to produce difficult products with accurate dimensions. This study aimed for modelling and simulation of original and modified air vents of the personal computer to analyze the resources saving along with improved system performance. The design of air vents prepared using SolidWorks software package. The ANSYS is used to simulate the physical model of air vents for its performance. Three models with rectangular, strainers type and trapezoidal type air vents have been created. The findings shows that through the modified design to trapezoidal cross section of air vent and fabrication through FDM technology, saves the material and also improves the system performance which improves lifecycle of system components.***

Keywords: Air Vent, Material, Fused Deposition Modeling

1. Introduction

The overheating of personal computer is the common problem due to more parts and functions available in system. Due to many chipsets, memory units and other processing accessories causes overheating and life cycle related problems [1]. The production of these complex and light weight units is also sensitive. The traditional manufacturing methods required larger inventory and create a material waste [2]. Waste material also affect to the environment [3]. In many weight sensitive applications FDM process and efficient design of component will minimize material and energy consumption[4]. Further the fabrication of complex geometry through FDM process the system performance and material saving enhances. Therefore, this study has planned to evaluate the effects of air vent design on cooling performance of system and material consumption when fabricating through FDM technology.

Additive manufacturing (AM) techniques have the potential to produce complex items for mechanical and electronic applications using metallic, polymeric, ceramic or composite materials. It is one of the fast developing advanced digital manufacturing techniques in the world technologies [5]. The material extrusion technique is most widely associated with additive manufacturing [under the trademark Fused Deposition Modeling (FDM®)]. In FDM technology the polymer fiber is melted and extruded through a nozzle of specific diameter to create intricate parts in layer by layer manner. The FDM technique has some unique advantages such as efficient production of functional and complex geometries at lower cost. These unique features of FDM system allow it to consider for complex and sensitive product such as air vents of laptop. The filament used in FDM system is usually of circular cross section with diameters of either 1.75 mm or 3.0 mm [6]; [7]. Another characteristic of FDM technology is the range of material compatibility. The polymer material has relatively lower cost, durability, light weight and its thermal conductivity is up to 100 times lower than metals. Lower conductivity could be helpful for avoiding the overheating of system. This is obvious a beneficial characteristic for mechatronics application [8].

In the last decade both market size and applications areas of AM expanded at a rate of 33% per year (Wohler's, 2014). The global trend of additive manufacturing (including systems, materials, and services) is rising rapidly and expected to ~\$21.0 billion in 2020 (Wohler's associates 2015). The people (Song et al) predicted that after a decade, all critical and non-critical spare products will be produced through AM technologies. The consumer products and electronics are the major sectors which using AM more than 22% compared to other areas [9].

The development of model which can provide better performance of system and consumes less resources are necessary for many devices. Especially, the personal computer required such model that can equipped with efficient cooling system. The efficient cooling system improves the life cycle of the surrounding components. Therefore, this study aimed for modelling and analysis of air vents for laptop cooling performance and material consumption. The SOLIDWORKS software is used to create the model of system with different air vents and the analysis has been done through ANSYS software package.

1.1. Components of personal computer

The computer is one of the more complex electronic devices which have many small accessories. The air vent is one of them which is responsible for the safe life of other surrounding components. The main role of air vents in personal computer is to produce the desired cooling inside the system. It is a passage through which either the air sucks or extracts. The design of any component plays an important role in saving of manufacturing material and system performance [10]. The figure 1 indicates the components of system which have to be cool through different models of air vent. The entire assembled system with two air vents has surrounding components such as CPU, HDD drive, Battery, RAM, graphic card, flash storage etc. The maximum limit of operating temperature for every component has been specified through the literature support.

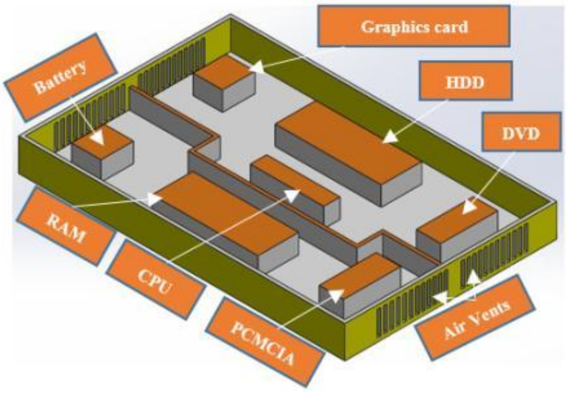


Figure 1 CFD model of laptop

1.2. Importance of air vent geometry

The geometry of air vent has a significant impact on the computer cooling performance and resource saving. For the better cooling performance and to produce light weight laptop, it should maintain the following;

- The intake side geometry of air vent should be designed in such a way, so that it does not obstruct the entering air.
- The inlet air velocity should be more to increase the heat transfer rate throughout the system.
- It should consume minimum material as these are very costly and produced through complex processes.
- The proper cooling and ventilation of system improve the life cycle of system components and smooth working.

The methodology is to achieve the above properties of system considering performance of personal computer with material saving as major factors is discussed in the next section.

2. Methodology

The steps used in methodology are indicated in figure 2. The two main activities including modelling and simulation have been performed in this study. The SOLIDWORKS software is used to create the system model with different air vent and ANSYS is used for simulation purpose.

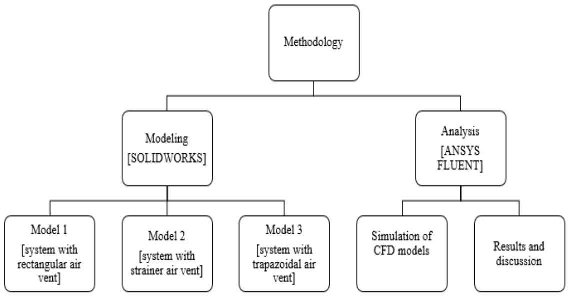


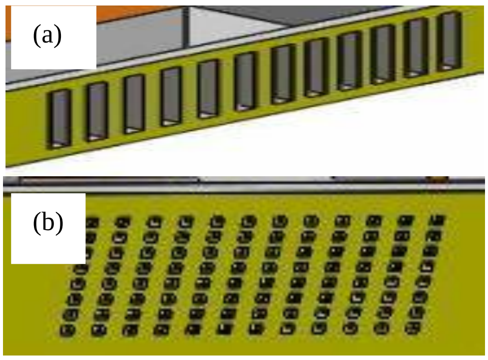
Figure 2 Steps used in methodology

2.1 Finite element model

The significant performance of system is also affects by the proper functioning of surrounding components. The proper cooling of these components is affected by the efficient design of air vent. The finite element model of air vent is created to measure its cooling performance for the system. In this study the customization of air vent geometry is considered as a variable. Three FEM models with rectangular, strainer and trapezoidal cross section of air vent have been developed. The ANSYS FLUENT software is used to analyze this model for system performance.

2.2. Air vent models

The base model for CFD analysis is taken from the reference the design of air vents of personal computer allows the air for inflow and outflow, which cools the internal parts of computer. The optimum design of air vents can improve the computer performance by providing the proper ventilation without any air restriction. The geometry should be designed in such a manner so that it should not suck unwanted dust and garbage which causes the obstruction in vents causes overheating. In this study, for entry side of air vent it is considered the lesser obstacle for entering air with minimum dust particles and for exit side the easy discharge of air is considered. These considerations first improve the cooling performance of system and second reduce the material consumed in air vent fabrication. The reduced amount of dust entered will also enhances the life cycle of system accessories. The air vent with different design for comparing the system performance and material volume used in fabrication are shown in figure 3 (a, b &c). The study has taken rectangular, strainer type and trapezoidal type cross section of air vents.



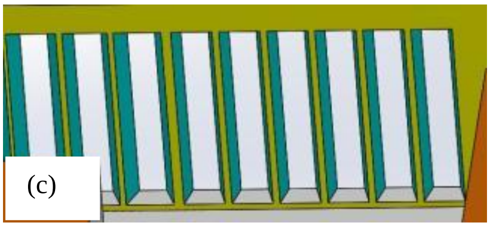


Figure 3 [a, b, c] Designs of air vents

3. Results and Discussion

The cooling performance of system using different air vents design has been evaluated. Based on pre-defined initial and boundary conditions the third model with trapezoidal air vent design provides the better results for both, system performance and material consumption. The temperature distribution for first model with rectangular cross section is shown in figure 4. The change in temperature of every component also displayed in this figure. The figure 5 shows the temperature distribution in system with strainer type air vent.

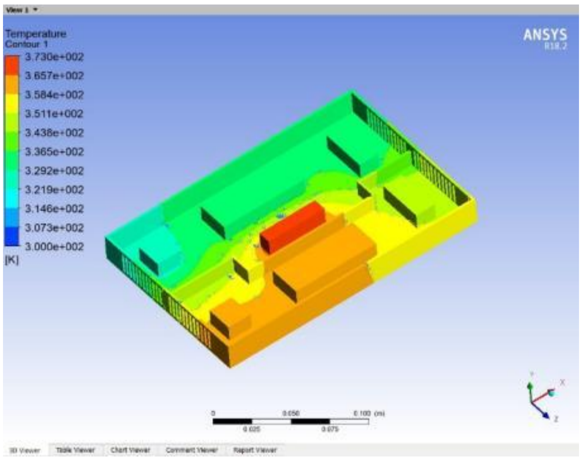


Figure 4 Temperature distributions in system with rectangular air vent

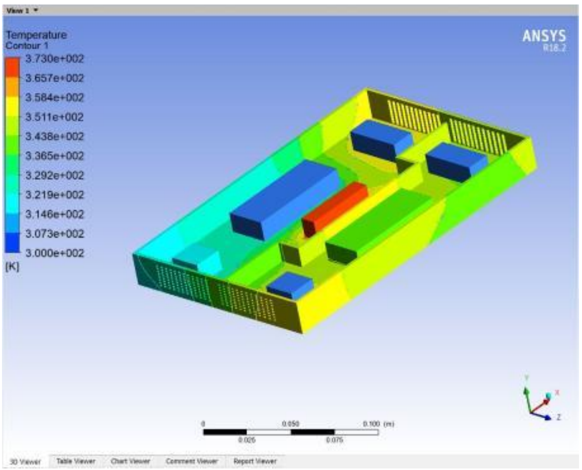


Figure 5 Temperature distributions in system with strainer type air vent

The system with air vent of trapezoidal cross section is shown in figure 6. The performance of this model is found to be better among all models.

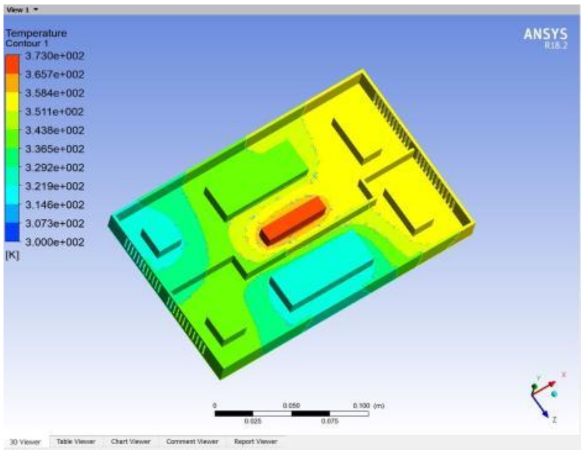


Figure 6 Temperature distributions in system with trapezoidal air vent

The material consumption in different models have been calculated by considering a particular section of model. The order of material volume considering single strip is strainer type> rectangular type > trapezoidal type. Table 1 shows the temperature distribution for systems with different air vent models. The results are indicating that air vent with trapezoidal cross section is better for cooling performance and material saving.

Table 1 Temperature distribution in laptop models with different air vents (K)

Component	Model 1	Model 2	Model 3	T_{max}
CPU	318	323	314	373
RAM	316.5	321.3	312.2	343
HDD	314.2	324	316	333
Graphics card	312.4	321.7	316.6	358
South Bridge	312	317.3	311	358
PCMCIA	310.3	312.5	306.8	343
Battery	315.7	320.8	307	328

The design of components plays an important role in the system performance where it is used. The optimized geometry of air vents improves the system performance and saves the manufacturing material. From the obtained results it has been observed, that the temperature drop is more in trapezoidal air vent design [model 3] compared to other model [1 &2]. The figure 7 is representing the variation in temperature distribution with respect to system components equipped with different air vent models. The line of maximum temperature indicating that CPU and Graphic card are possesses the highest temperature.

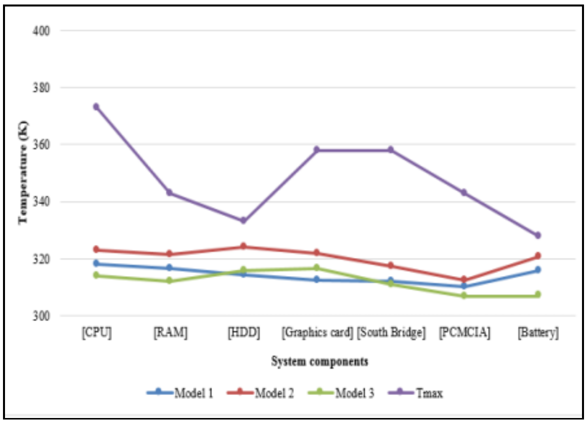


Figure 7 Temperature distributions in different models

Among three air vent models the strainer type model shows the minimum temperature drop across the system. Whereas the trapezoidal type model shows the maximum values of temperature drop across almost all components of the system. The green line in above figure is indication the performance of trapezoidal type model of air vent. The model 1 shows the better temperature drop across HDD and Graphic card than model 2. The geometric effect on cooling performance of laptop system and material saving investigated. It is found that the geometry of product has potential effects on resources saving and system performance.

4. Conclusions

The effects of air vent models on system cooling performance and material volume have been investigated. The following conclusions have been drawn from this study;

- The air vent model with trapezoidal cross section gives the better air circulation which carried out the maximum heat from system. It provides better cooling solution for the system as found through CFD analysis. The trapezoidal air vent provides the drop of temperature up to 314 K from its maximum working temperature 373 K. The temperature drop of system in case of trapezoidal air vent is 15.9%, rectangular air vent is 14.74% and in strainer air vent is 13.5%, which shows efficiency of trapezoidal air vent system.
- The material volume calculated for single strip air vent for all the three air vent models are 45mm^3 of rectangular air vent, 55.4mm^3 of strainer type air vent and 28.125mm^3 for trepazoidal air vent, which shows that volume of trapezoidal air vent is less.
- The fabrication of customized model of air vent is not easy through traditional methods. The AM technology could enable to produce such air vent model with minimum complexity.

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Author Profile

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