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Thermal Analysis of a Nokia Lumia 900 Model Cellular Phone Using Ansys

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Abstract

"Necessity is the mother of invention"- *one of the most important and interesting man made inventions is cellular phone. There is a rapid increase in the number of users of cellular phones in the last decade. The use of cellular phone has become an integral part of our lives. In this paper, an attempt is made to study of 3-Dimensional heat transfer phenomena in Nokia Lumia 900cellular phones using 'Finite Element analysis'. The actual dimensions and materials for chosen forNokia Lumia 900.Then, cellular phone is modelled in Pro/E, then meshed by 3D-10 noded tetrahedral thermal solid elements (SOLID87) and analysed in ANSYS software. Then by applying boundary conditions, the analysis is carried-out and the nodal temperatures, Directional Thermal Fluxes are obtained and validated with the references.*

1. Introduction

Cellular phones, also known as mobile phones or wireless phones, are hand-held phones. Unlike home phones, cellular phones can be carried from place to place with a minimum of fuss. Mobile phones were introduced in the mid-1980s and in the last two decades their ownership and use has increased dramatically. Cellular phones are a vast improvement over the telecommunications technology of the past, and are daily becoming a fixture of modern life. Apart from all the advantages, cellular phones do have some limitations like over usage results in health hazard. But, no other product in the market has that much demand as a cellular phone.

2. Literature Review

Aaron Carroll [4], 2004 has presented a seminar on "An Analysis of Power Consumption in a Smartphone" in NICTA A detailed analysis of the power consumption of a recent mobile phone, the Openmoko Neo Freerunner was performed by him and measured not only overall system power, but the exact breakdown of power consumption by the device's main hardware components.

Ronan Grimes and Ed Walsh [6], 2010 has presented a seminar on" Active cooling of a mobile phone handset". This paper presents the power dissipation levels in mobile phones continues to increase due to gaming ,higher power applications and increased functionality associated with the internet. The current cooling methodologies of natural convection and radiation limit the power dissipation within a mobile phone to between 1-2W depending on size. As power dissipation levels increase, products such as mobile phones will require active cooling to ensure that the devices operate within an acceptable temperature envelope from both user comfort and reliability perspectives.

Professor Frank Fisher [7], 2012 has presented a seminar on "Modeling and Simulation 3D Heat Conduction within a solid-cell phone". This paper presents the 3D geometries in heat transfer by modeling an object subjected to requirements and specific boundary conditions. Using ANSYS nodal temperature distribution was determined.

3. Introduction to Meshing

Meshing can be defined as the process of breaking up a physical domain into smaller sub-domains (elements) in order to facilitate the numerical solution of a partial differential equation. While meshing can be used for a wide variety of applications, the principal application of interest is the finite element method. Surface domains may be subdivided into triangle or quadrilateral shapes, while volumes may be subdivided primarily into tetrahedral or hexahedra shapes. The shape and distribution of the elements is ideally defined by automatic meshing algorithms.The mesh influences the accuracy, convergence and speed of the solution.

Here the cell phone models are meshed by treating the cell phone elements as 3D-10 noded tetrahedral thermal solid elements (SOLID87).

3.1 Material Properties

Go to the ANSYS Main Menu Click Preprocessor> Material Props> Material Models,Choose Thermal> Conductivity> Isotropic (Double click).

Choose Define Material Model Behavior > Material> New Model and define conductivities for the model, that of innards 10 W/m-K and for the next material plastic case as 0.12 W/m-K, NOKIA LUMIA 900 : 127.8mm long x 68.5 mm wide x11.5 mm thick

Figure:1 Nokia Lumia 900

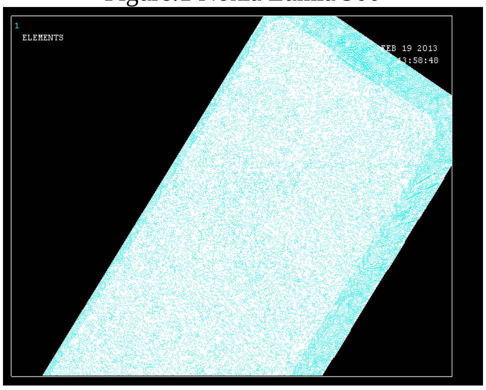

Figure: 2 Meshed Display of Lumia 900

The above meshed part gets checked in ANSYS for to analyze heat transfer of cellular phone.

4. Analysis

Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user designed size) called elements. The software implements equations that govern the behaviour of these elements and solves them all creating a comprehensive explanation of how the system acts as a whole. This type of analysis is typically used for the design and optimization of a system for too complex to analyse by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations. The following types of analysis are Thermal, Fluid flow, Magnetic, Acoustics/ vibration and Coupled fields. ANSYS is general-purpose finite element analysis (FEA) software package.

4.1 Thermal Analysis

ANSYS is capable of both steady and unsteady state and transient analysis of any solid with thermal boundary conditions. Steady-state thermal analysis calculates the effects of steady thermal loads on a system or component. Users often perform a steady-state analysis before doing a transient thermal analysis, to help establish initial conditions. A steady-state analysis can also be the last step of a transient thermalanalysis; performed after all transient effects have been diminished. ANSYS can be used to determine temperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. Such loads include the following: Convection Radiation, Heat flow rates Heat fluxes (heat flow per unit area).

A steady-state thermal analysis may be either linear, with constant material properties; or nonlinear, with material properties that depend on temperature. The thermal properties of most material vary most material vary with temperature. This temperature dependency being appreciable, the analysis becomes nonlinear. Radiation boundary also makes the analysis nonlinear.

4.2 Procedure for ANSYS analysis

The procedure for ANSYS analysis can be divided in to three distinct steps.

1. Build the model.
2. Apply boundary conditions and obtain the solution.
3. Review the results.

4.3 Pre-processing

The basic steps to build the model for an ANSYS analysis

1. Specify the job name and title. Enter PREP7 (ANSYS pre--processor).
2. Specify the element types.
3. Specify the element real constants.
4. Specify the material properties.
5. Define the model geometry.
6. Exit PREP7

To obtain the solution the basic steps in the solution phase vary depending on the type of analysis being performed. A summary of the basic steps in the solution phase follows.

1. Enter solution.
2. Specify the analysis type.
3. Apply the boundary conditions.
4. Start the solution.
5. Exit solution

4.4 Boundary conditions:

Apply Convection- Film Coefficient as 50 W/m2K and Bulk Temperature as 300K

Apply Heat Generation- Pick the battery part only and place the magnitude of Heat Generation as 139843 W/m3

(The voltage of the battery is rated as 4 voltsinternal resistance is on the order of 200 milli-ohms

The total power is I2R = 3.200 Watts i.e., the total power per unit volume is 139843 W/m^3)

4.5 Post-processing

Post process in means review in the results of an analysis. It is probably the most important step in the analysis, because we are try in to understand how the applied boundary conditions affect your design, how good your finite element mesh, and so on.

4.6 Solutions

- Go to Main Menu>Solution>Analysis Type>New Analysis
- Select Steady State
- Go to Solution>Solve

5.0 Results

5.1 Introduction

The analysis is carried out for nodal temperatures distribution, thermal flux and thermal errors distributions in all the three dimensions (x, y, z).

- The thermal analysis (or) contour plots of cell phone are shown in fig.5 to fig7
- The maximum and minimum values of nodal temperatures, thermal fluxes are tabulated

5.2 Nodal temperature distribution

Nodal temperature: nodal temperature is defined as the temperature existing at each every node.

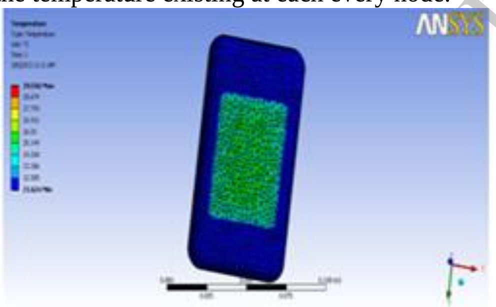

Figure.3 Nodal Temperature Distribution of Cell phone – Isometric View

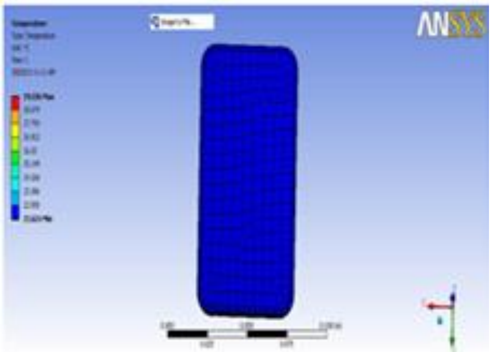

Figure. 4 Nodal Temperature Distribution of Cell phone – Front view

5.3 Heat fluxes:

Heat fluxes are surface loads. Use them when the amount of heat transfer across the surface (heat flow rate per area) is known, or is calculated through NSYS. A positive heat flux indicated heat flowing into the element. Heat flux is used only with solid and shells.An element face may be either CONV (or) HFLUX specified as a surface load.

Click on Insert Thermal Results>Directional Heat Flux>Solve

Thermal fluxes for NOKIA lumia 900 are found along X - direction. From fig 5 Red colour indicates the maximum thermal flux and blue colour indicates the minimum thermal flux.The maximum value is 210 W/m^2 and the minimum value is-200.3 W/m^2.

Thermal fluxes for NOKIA lumia 900 are found in Y-direction. From fig 6 Red colour indicates the maximum thermal flux and blue colour indicates the minimum thermal flux. The maximum value is 208.3 W/m^2 and the minimum value is -165.33 W/m^2.

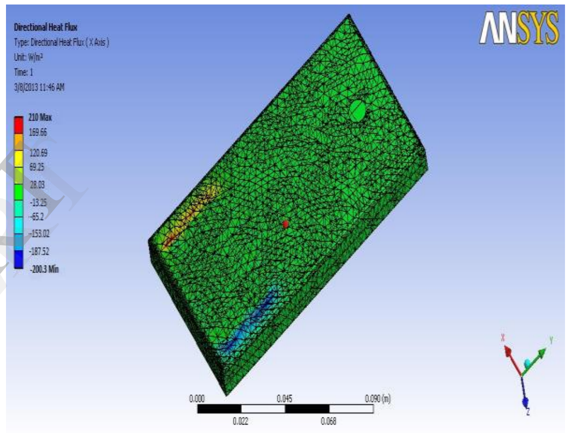

Fig 5: Thermal Flux for Nokia lumia 900 along X-Direction - Rear View

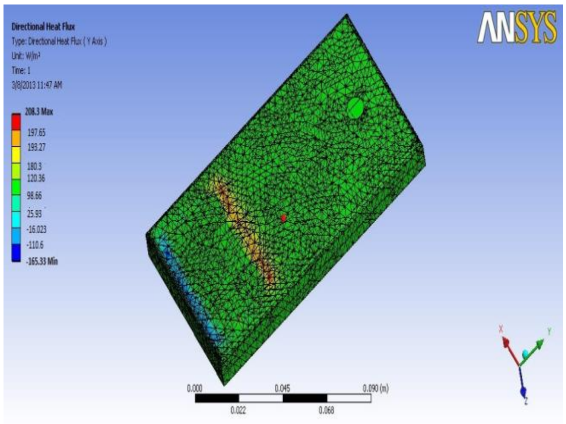

Fig 6: Thermal Flux for Nokia lumia 900 along Y-Direction - Rear View

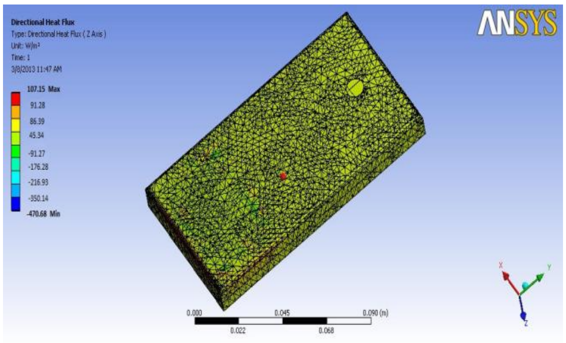

Fig7: Thermal Flux for Nokia lumia 900 along Z-Direction - Rear View

Thermal fluxes for NOKIA LUMIA 900 are found along Z - direction. From fig 7 Red colour indicates the maximum thermal flux and blue colour indicates the minimum thermal flux.The maximum value is 107.15 W/m2 and minimum value is -470.68 W/m2.

6. Summarized Results:

Table 1

S.No	Type	Nokia Lumia 900	
		Min	Max
1	Nodal Temperature(K)	300	302.85
2	Thermal flux (W/m²) Along X Along Y Along Z	 -200.30 -165.33 -470.68	 210.00 208.30 107.15

NOTE: The '-' sign indicates the direction of heat transfer

6.1 Validation of Results:

Table 2

S. No	Type	**Nokia 3360**		**Referred paper results**		**Present project results**	
		Min	Max	Min	Max	Min	Max
1	Nodal temperature(K)	294.01	302.32	294.01	302.32	300	302.85

7. CONCLUSION AND FUTURE WORK

In cell phones heat will be generated. For efficient working of cell phones and to prevent inconvenience for the users. The generated heat must be efficiently transferred. If the heat dissipation is not effective then the users feel inconvenience. By doing the thermal analysis of cell phones, it is possible to study the heat transfer phenomena occurring in cell phones i.e., temperature at all points, thermal fluxes and thermal gradients.

If the temperatures are more then the user may feel discomfort. So that the temperature ranges in cell phone must be near to body temperature. Generally body temperature is 303 k.

In the first step of analysis by giving boundary conditions then it observed that the out the maximum and minimum nodal temperatures are

- The maximum nodal temperature is 302.85 (K)
- The minimum nodal temperature is 300 (K)

7.2 Future work

In future, this work may be preceded based on Size Optimization, Material Optimization, Cost Optimization.

8. References

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