Gaussian Thermal Boundary Condition Implementation over Rectangular Plate for Finite Element Analysis using ANSYS Tool

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Abstract— Boundary condition application in finite element analysis is very important as per find out behaviour of any physical model before it put in real application. Proper application of boundary condition approach toward true behaviour of any physical object in real application. A number of fields such as Gaussian beam characterization and emission and absorption line spectroscopy work with sampled Gaussian functions and it need to accurately estimate the position, and width parameters of the function. In this paper discuss about implementation of Gaussian thermal boundary in finite element analysis using ANSYS tool. In this paper simple rectangular plate is to be taken to apply thermal boundary condition on it is front face for example.

Key word: FEA, MATLAB, ANSYS

I. INTRODUCTION

The Finite Element Analysis (FEA) is a numerical method for solving problems of engineering and mathematical physics. finite element analysis (FEA), is a computational technique used to obtain approximate solutions of boundary value problems in engineering. Finite Element Analysis is used as a design tool within engineering industries due to the capability analysis accompanied by the different software package. In the case of thermal error modelling, simplifications are made when representing thermal boundary conditions such as the application of a uniform temperature parameter with parts assembled in both horizontal and vertical orientations. Performing a Design of Experiments it was possible to obtain the functional relation between the Mesh Element Size and the FE results. The finite element method differentiate between natural and essential boundary condition. the boundary condition integrands represent a physical quantity for example , flux in a thermal diffusion problem, stress in a linear elastic problem. the condition is directly implemented by substituting if integrands is known or by substituting an expression involving unknown, as a radiation condition for example. Natural boundary condition is specified at the time of PDE problem specified. on other hand an absolute specification at some set of boundary node is called an essential boundary condition. This work is focus on obtaining thermal parameters related to applying thermal Gaussian temperature on areas of simple rectangular plate as inputs to the FEA. However as the model gets larger (In FEA, larger model does not mean larger geometry, but rather the complexity due to the number of elements used), the computer will spend more time to generate the results of the analysis. It also provide details on how to apply Gaussian boundary condition parameters form it mathematical equation. The significance of this work is to improve applying FEA thermal boundary condition, which are a critical part of engineering design. Although the focus is on any design, the process and parameters can equally be applied to other areas of thermodynamic behaviour.

II. METHODOLOGY

The application of boundary condition in the finite element method require either that some information is used to replace the integrand resulting from second order term or that for such test function the whole equation is replaced by essential condition. Boundary condition application Consumes least time but it is the most important step. all other work without applying proper boundary condition . After completion of pre-processing i.e. CAD, Meshing and Boundary conditions, software internally forms mathematical equations of the form [F] = [K] [δ]. The boundary condition integral often have physical significance and it is best to try to formulate the equation. in many second order equation correspond to one of pattern like time rate change of heat = div(flux). for steady state condition time rate is zero. For initial study boundary condition of temperature apply on the rectangular plate. For example Gaussian distribution of temperature can be define as

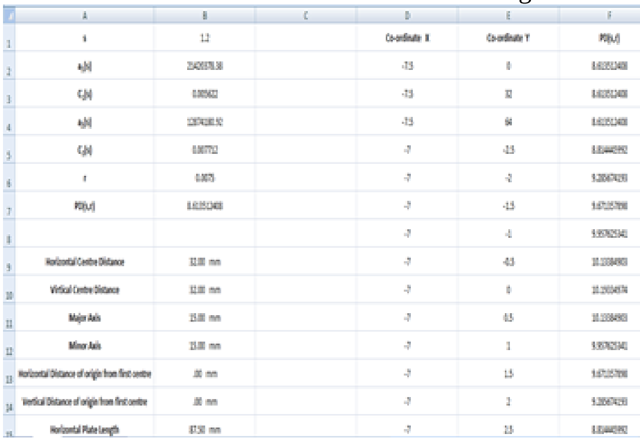
$$\text{temperature}\ (r) = A \cdot e^{-\left(\frac{r}{C}\right)^2} + B \cdot e^{-\left(\frac{r}{D}\right)^2}$$

Where r is the radius of beam on which temperature is distributed as per Gaussian curve, value of A, B, C and D is constant . Software particularly useful for linear algebra is MATLAB. MATLAB is a tool for solving differential equations for numerical integration. MATLAB is also useful for signal processing, image processing, optimization. It is also a programming language, and is one of the easiest programming languages for writing mathematical programs. For evaluating Gaussian curve first write program for the Gaussian equation with help of MATLAB tool which can be converted in to MACRO file as shown in below in figure 1. Once An algorithm for estimating the Gaussian function parameters is prepared than, it is important to know about how accurate those estimates is.

```
Range("D2:F3").Select
Range(Selection, Selection.End(xlDown)).Select
Selection.ClearContents
Range("D2").Select

s = Cells(1, 2).Value
a = Cells(9, 2).Value
b = Cells(10, 2).Value
Mj = Cells(11, 2).Value
Mn = Cells(12, 2).Value
c1 = Cells(13, 2).Value
c2 = Cells(14, 2).Value
l1 = Cells(15, 2).Value
l2 = Cells(16, 2).Value
res = Cells(18, 2).Value
th = Cells(17, 2).Value * (WorksheetFunction.Pi() / 180)

c = 0
x = -7.5
While x <= 11
y = -7.5
While y <= 12

i = (Abs(((WorksheetFunction.Round((Abs(x - c1) / a), 0)) * a) - (x - c1))) * (Cos(th))
j = Abs(((WorksheetFunction.Round((Abs(y - c2) / b), 0)) * b) - (y - c2))

r = Sqr((i ^ 2) + (j ^ 2))

If r <= (Mn / 2) Then
c = c + 1
Cells(6, 2).Value = (r / 1000)
Cells(1, 2).Value = s + ((x * Sin(th)) / 1000)
n = Cells(7, 2).Value / Cos(th)
Cells(c + 1, 4) = x
Cells(c + 1, 5) = y
Cells(c + 1, 6) = n
```

Fig. 1: Macro file in Excel

Above program output generate data point in prescribe surface boundary with 0.5 megapixel pixel size, value of temperature vary with the function coefficient variation based on r value. as we define boundary condition with 7 mm radius total data point covered with this surface at pitch of 0.5 mm . temperature data generated on x and y coordinate point value as given below figure 2. Data can be stored in notepad file as a text data. for ANSYS interference select external data from the ANSYS workbench toolbar and import this text data file into external data file with tab delimited form as shown in below figure 4.



	A	B	C	D	E	F
1	x	1.2		Co-ordinate X	Co-ordinate Y	P0(x,y)
2	a1(x)	21420378.38		-7.5	0	8.61351408
3	C1(x)	0.005622		-7.5	32	8.61351408
4	a2(x)	12874180.92		-7.5	64	8.61351408
5	C2(x)	0.007712		-7	-2.5	8.81440992
6	r	0.0075		-7	-2	9.20674193
7	P0(x,y)	8.61351408		-7	-1.5	9.67105798
8				-7	-1	9.95762541
9	Horizontal Centre Distance	32.00 mm		-7	-0.5	10.1384903
10	Vertical Centre Distance	32.00 mm		-7	0	10.1904874
11	Major Axis	15.00 mm		-7	0.5	10.1384903
12	Minor Axis	15.00 mm		-7	1	9.95762541
13	Horizontal Distance of origin from first centre	.00 mm		-7	1.5	9.67105798
14	Vertical Distance of origin from first centre	.00 mm		-7	2	9.20674193
15	Horizontal Plate Length	87.50 mm		-7	2.5	8.81440992

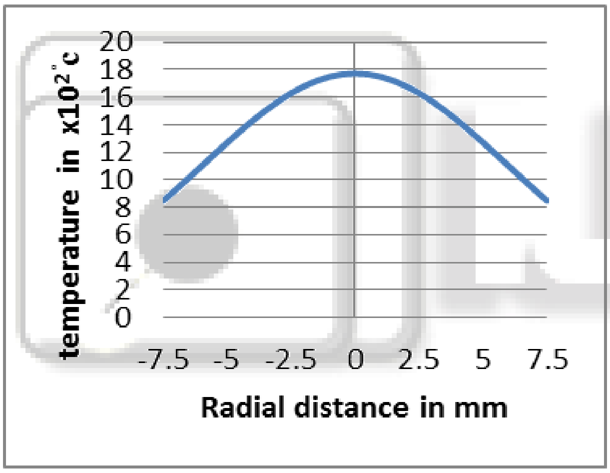


Fig. 2: Output macro file data point.

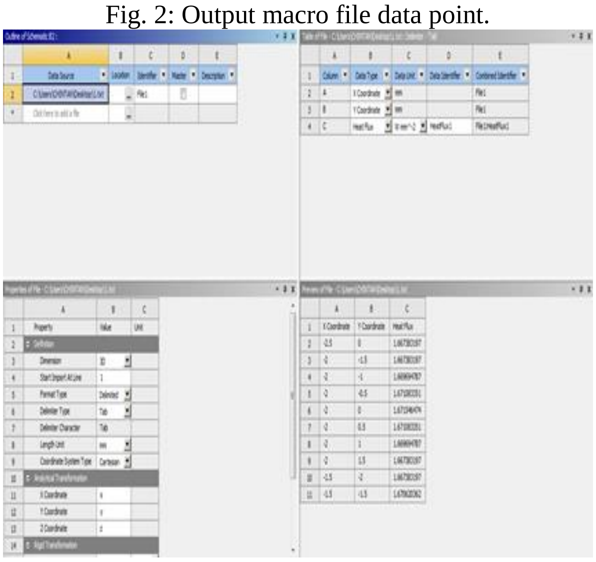


Fig. 3: Data point in external data setup

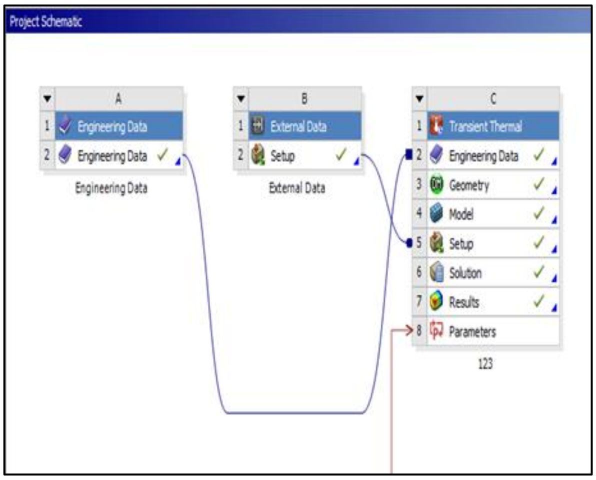


Fig. 4: ANSYS interference

III. Result and Discussion

As we define the Gaussian distribution of any beam with some mathematical expression and this mathematical expression can be converted in to an excel file data with help of macro tool. Output of data in form of source point data and temperature value. As shown in below figure circular face boundary which is pre-defined for implementation of temperature converted in number of small data point and heat load distributed according to equation result in macro file data.

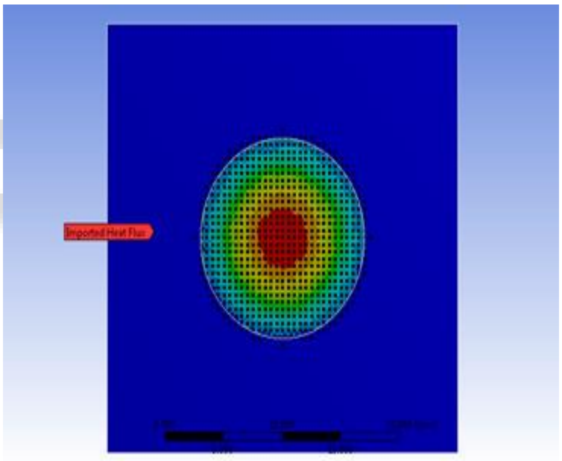


Fig. 1.4: Output of Gaussian load on front of rectangular plate with source data

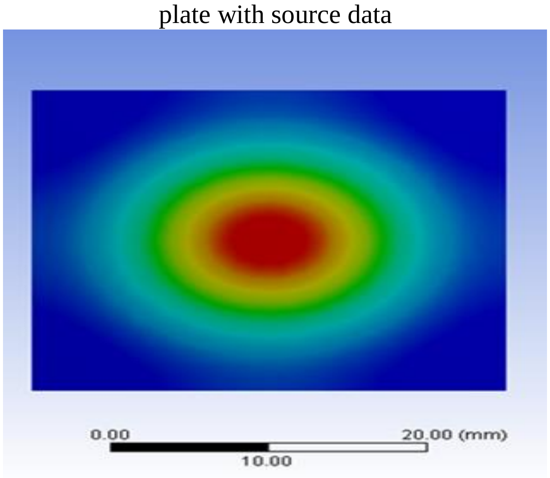


Fig. 5: Heat Flux Distribution Over Plate Surface

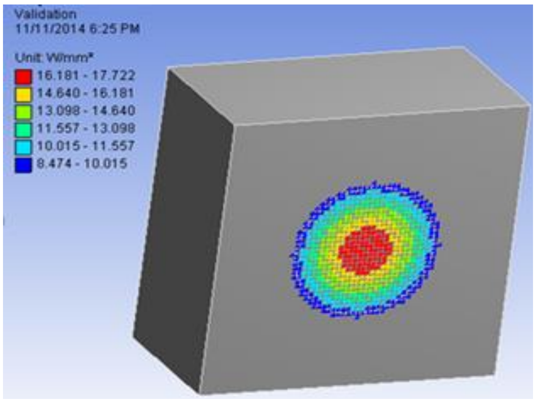


Fig. 6: Validate Result Of Heat Flux

As show in above figures Gaussian temperature load condition heat flux distributed accordingly Gaussian curve of temperature. as well as validation of heat flux value across the circular boundary condition.

IV. CONCLUSION

As seen above discussion in this paper we can derive methodology for the implementation any Gaussian thermal boundary condition for the finite element analysis. MATLAB program and excel datasheet we can generate data point value and can be directly import into ANSYS tool. so that any Gaussian load which is in term of its radial distance can be transfer in number of data point on the boundary surface and evaluate result of analysis.

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