MeshFree Benchmark Series
免網格分析軟體-基準測試

Verification of Thermal Analysis
熱分析驗證

01 Cooling FIn

問題定義

A cooling fin 1x1x8 inch is surrounded by fluid with one end maintained at temperature T=100 F, and the other end insulated (Fig. vt01). Find the temperature at the insulated end.

單位: IPS

材料屬性

thermal conductivity k = 25 BTU/(hr-ft-F), thermal convection coefficient h = 1BTU/(hr-ft^2-F).

條件和結果

Ambient temperature Ta = 0.

參考

Kreith, F. Principles of Heat Transfer. 2nd ed. P.A.: International Textbook Co., 1959, pg. 48

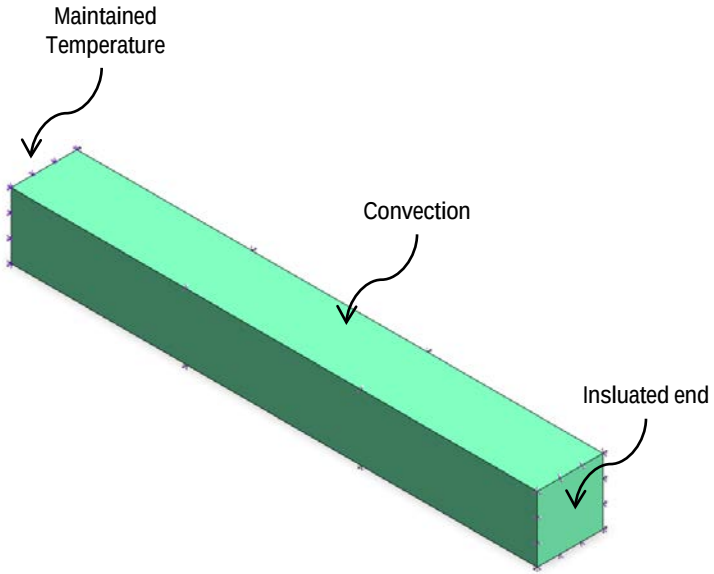
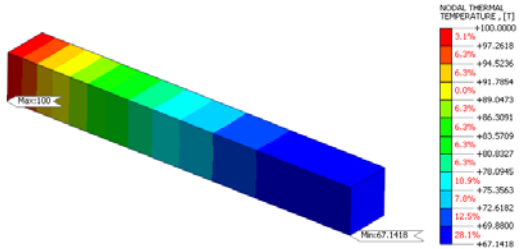
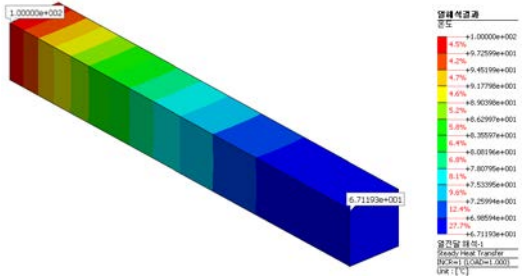
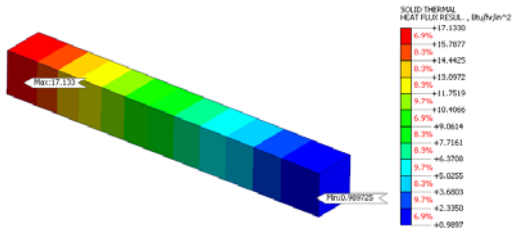
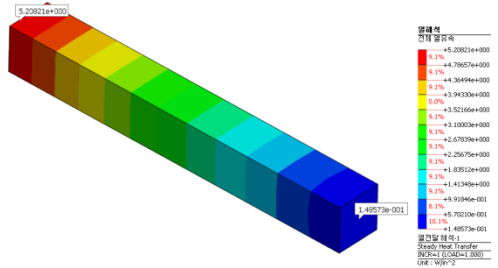


Fig. VT01

Mean Temperature at Insulated End

	溫度 [F]	誤差(%)
理論	68.592	-
FEM 有限元素 分析軟體	67.14	-2.12%
		
MeshFree 免網格 分析軟體	67.12	-2.15%
		

Thermal Flux Through the Heated End

	Heat Flux, [BTU/(hr-in^2)]	誤差(%)
理論	17.5	-
FEM 有限元素 分析軟體	17.13	-2.11
		
MeshFree 免網格 分析軟體	17.77	1.54%
		

02 Insulated Wall

問題定義

A wall consists of two layers (firebrick and insulating brick) of thickness 9 inch and 5 inch correspondingly. The temperature at firebrick surface is 3000 F and convection coefficient is 12 BTU/(hr-ft^2-F). The temperature at outer surface of insulating brick is 80 F and convection coefficient is 2 BTU/(hr-ft^2-F). Find temperatures at firebrick and insulating brick surfaces.

單位: IPS

邊界和負載

Ambient temperature Ta = 0.

材料屬性

firebrick thermal conductivity is 0.8 BTU/(hr-ft-F), insulating brick thermal conductivity is 0.1 BTU/(hr-ft-F).

參考

Kreith, F. Principles of Heat Transfer. 2nd ed. P.A.: International Textbook Co., 1959, pg. 32

求解結果

The wall is simulated by two solid blocks: 9x24x24 inch (firebrick), and 5x24x24 inch (insulating brick) (Fig. vt02). Thermal resistance in contact between the blocks is neglected. Side surfaces of the blocks are insulated in order to allow heat transfer only in the direction perpendicular to the wall.

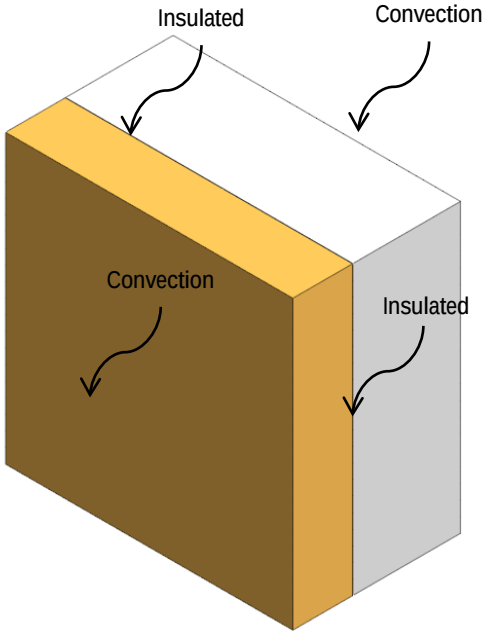
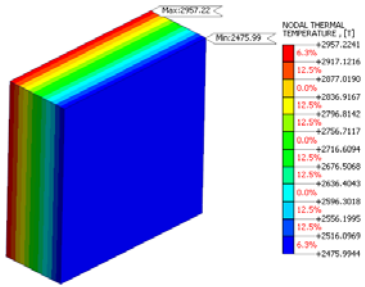
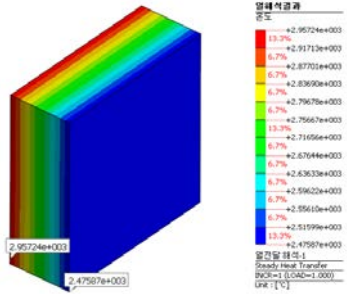
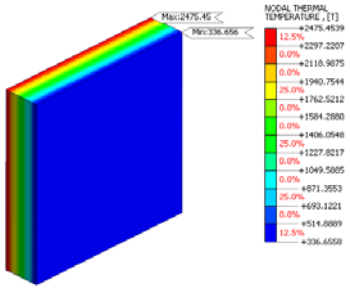
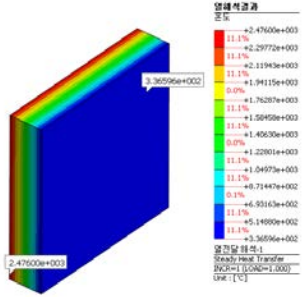


Fig. VT02

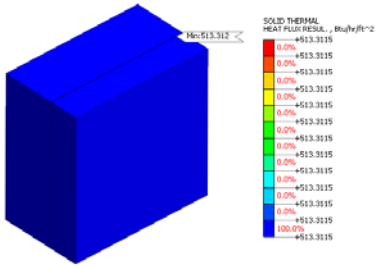
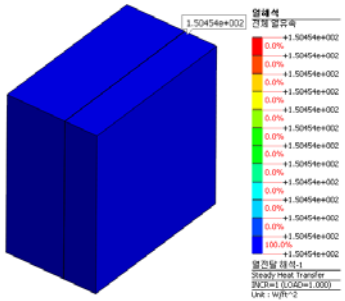
Temperature at Firebrick

	溫度 [F]	誤差(%)
理論	2957	-
FEM 有限元素 分析軟體	2957	0%
		
MeshFree 免網格 分析軟體	2957	0%
		

Temperature at Insulating Brick

	溫度 [F]	誤差(%)
理論	336	-
FEM 有限元素 分析軟體	336.7	0.21%
		
MeshFree 免網格 分析軟體	336.6	0.18%
		

Heat Flux Through the Wall

	Heat Flux, [BTU/(hr-ft^2)]	誤差(%)
理論	513	-
FEM 有限元素 分析軟體	513.3	0.06%
		
MeshFree 免網格 分析軟體	513.4	0.08%
		

03 Cylinder with Prescibed Heat Flux

問題定義

A cylinder is loaded with a prescribed heat flux along a strip on side surface (see Fig. vt03a). The bottom is maintained at zero temperature and the top and the rest of side surface are insulated. Find temperature at boundary between strip with applied flux and the rest of side surface of the cylinder (point A at Fig. vt03a).

單位: IPS

邊界和負載

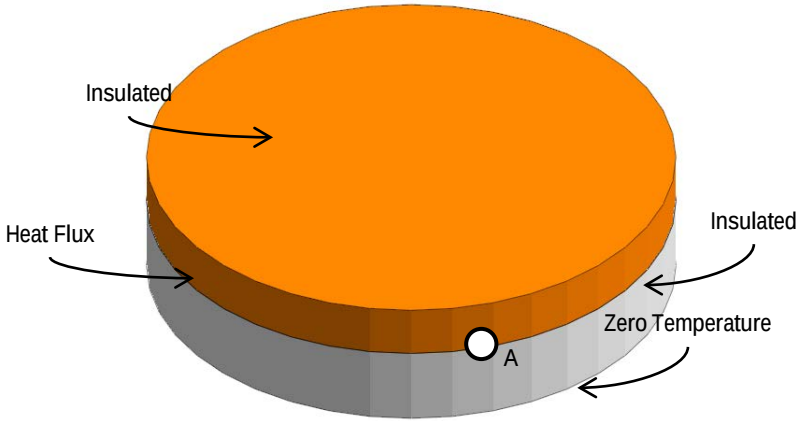
Heat flux value 5.e+5 W/(m^2).

材料屬性

thermal conductivity is 52 W/(m-K).

參考

This problem is a standard NAFEMS benchmark: NAFEMS, BMTTA (S), No. 15 (i). l.

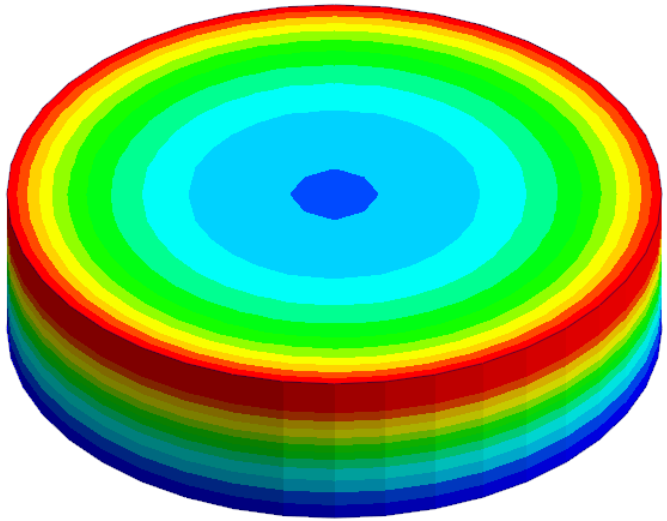


Cylinder height is 50 mm, diameter 200 mm, the width of the heat flux strip 20 mm.

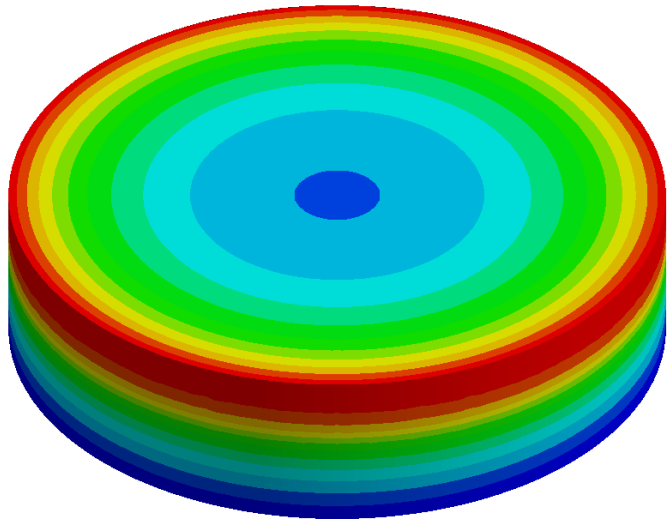
Fig. VT03

Temperature at Point A

	溫度 [C]	誤差(%)
理論	213.6	-
FEM 有限元素 分析軟體	213.8	0.09%



	溫度 [C]	誤差(%)
理論	213.6	-
MeshFree 免網格 分析軟體	212.6	-0.47%



04 Cantilever Beam Heat Transfer with Heat Source

問題定義

Figure 5.1.1 shows a one-dimensional steady state heat transfer problem with temperature dependent conductivity. The one-dimensional problem is discretized with 2 elements in the longitudinal direction with internal heat generation of 36000*J/m^3-hr* -in the element 2. The point A retains a fixed temperature of 5 *C.* The temperature at the midpoint B is determined.

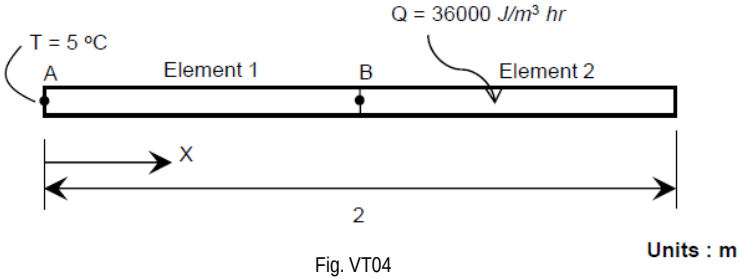


Fig. VT04

單位: SI

材料屬性

thermal conductivity is 10W/m-C

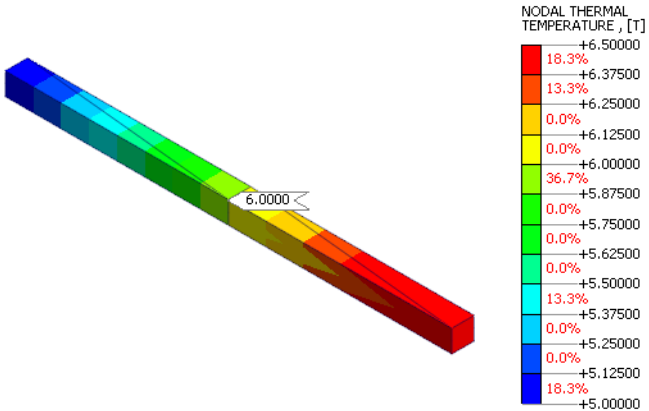
Secton Property is Rectangular Cross Section 0.1m x 0.1m

參考

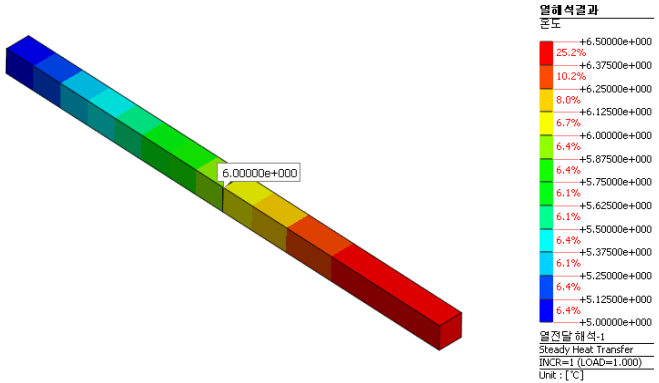
R.W. Lewis, K. Morgan, H.R. Thomas and K.N. Seetharamu, *The Finite Element Method in Heat Transfer Analysis*, Wiley, West Sussex, 1996

Temperature at Point B

	溫度 [C]	誤差(%)
理論	6.000	-
FEM 有限元素 分析軟體	6.000	0%



	溫度 [C]	誤差(%)
理論	6.000	-
MeshFree 免網格 分析軟體	6.000	0%



05 Cantilever Plate Heat Transfer with Convection

問題定義

Figure 5.2.1 shows a two-dimensional heat transfer problem. The temperature of 100 C is prescribed to the edge AB. On the edges BC and CD, convection boundary conditions are applied with an ambient temperature at 0C. The edge DA is insulated. Steady-state heat transfer analysis is carried out, and the temperature at the point E is determined.

單位: SI

材料屬性

thermal conductivity is k = 52J/m-hr-C

Convection Coefficient h = 750.0 W/m^2-C

參考

NAFEMS, *The Standard NAFEMS Benchmarks*, Rev. 3, NAFEMS, Glasgow, 1990

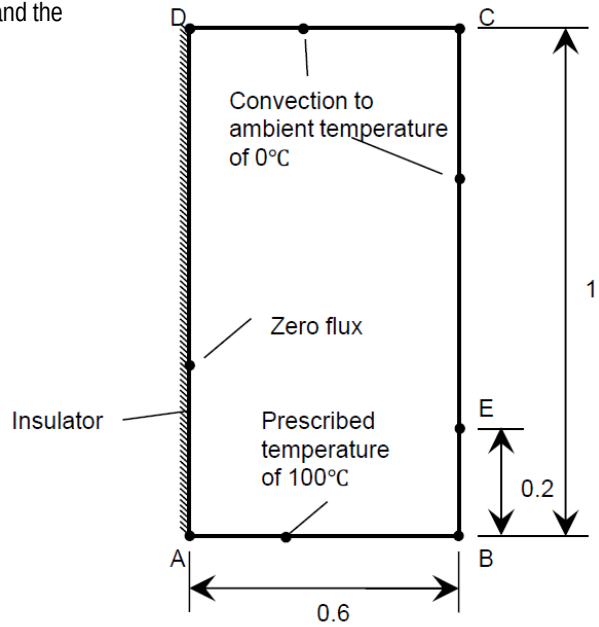
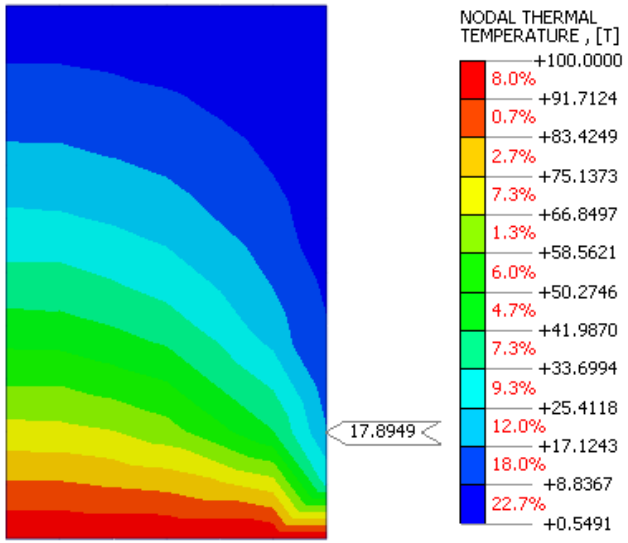


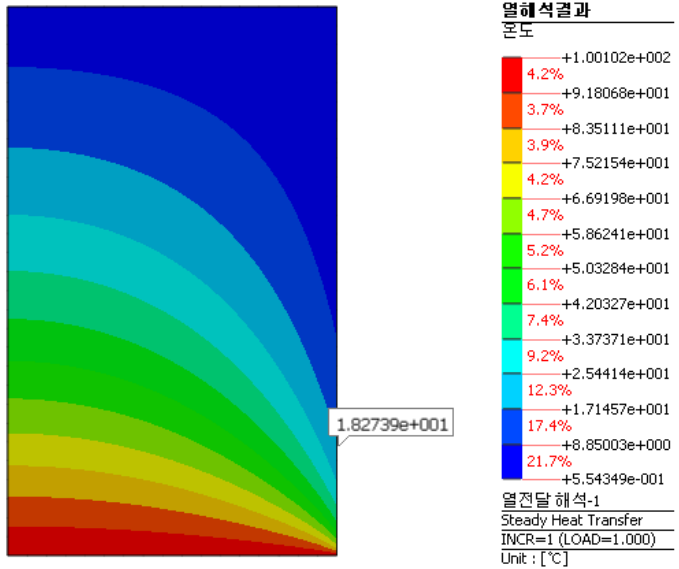
Fig. VT05

Temperature at Point E

	溫度 [C]	誤差(%)
理論	18.3	-
FEM 有限元素 分析軟體	17.9	-2.19%



	溫度 [C]	誤差(%)
理論	18.3	-
MeshFree 免網格 分析軟體	18.27	-0.16%



06 Two-dimensional heat transfer in bi-material

問題定義

Figure 5.3.1 shows a bi-material embedded in a high-thermal-conductivity material maintained at 400 □ *C*. The upper surface is exposed to a convection environment at 30*C*. The temperature at the points A and B are determined and compared with the referenced solution given in [5-3].

單位: SI

材料屬性

thermal conductivity is k = 2.0W/m-C (Material A)

k = 0.3W/m-C (Material B)

Convection Coefficient h = 25 W/m^2-C

參考

J.P. Holman, *Heat Transfer*, 9th Edition, McGraw-Hill, New York, 2002

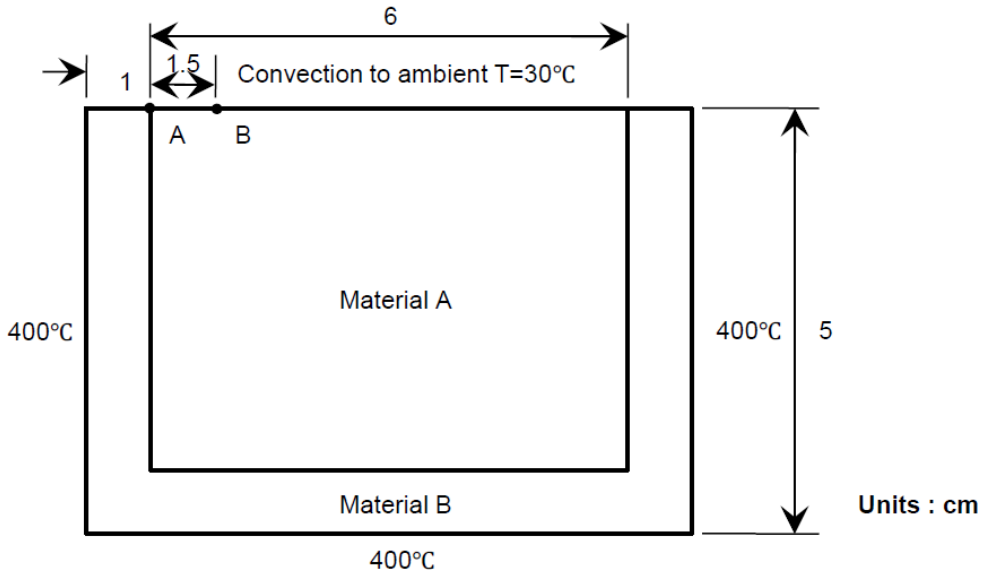
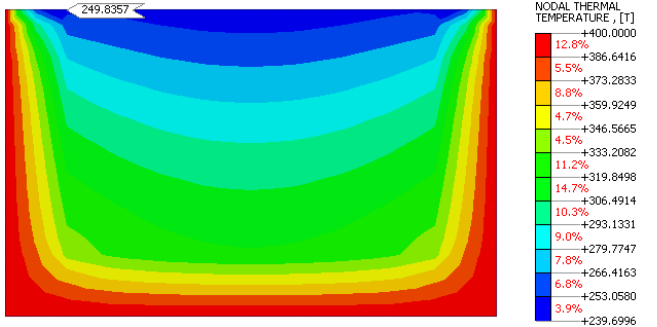
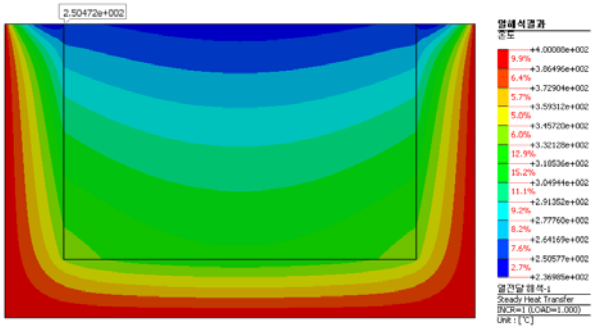


Fig. VM06

Temperature at Point A

	溫度 [C]	誤差(%)
理論	254.96	-
FEM 有限元素 分析軟體	249.84	-2.01%
MeshFree 免網格 分析軟體	250.47	-1.76%





Temperature at Point B

	溫度 [C]	誤差(%)
理論	247.64	-
FEM 有限元素 分析軟體	246.32	-0.53%
MeshFree 免網格 分析軟體	246.40	-0.50%