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Coil Size Optimization - Induction Heating

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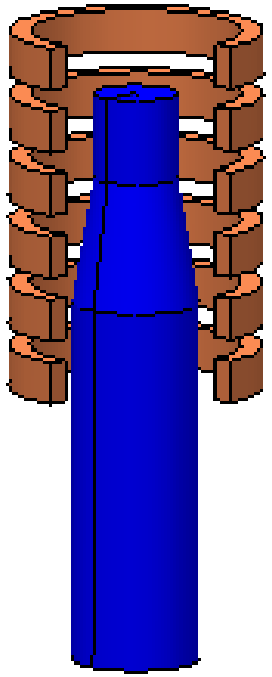
In the multiple-coil configuration shown in this figure, the work piece is surrounded by six coils (coils are shown partially so that the workpiece can be seen). The objective of this optimization is to find the inner radii of the coils in order to obtain a uniform temperature in the upper portion of the workpiece.



The coupled electromagnetic-thermal simulation is a transient thermal solution that, at each time step during the transient process, performs a time-harmonic electromagnetic solution to update the eddy current losses. The workpiece is made of stainless steel and its material properties are non-linear and vary with temperature.

IDENTIFYING THE PARAMETERS

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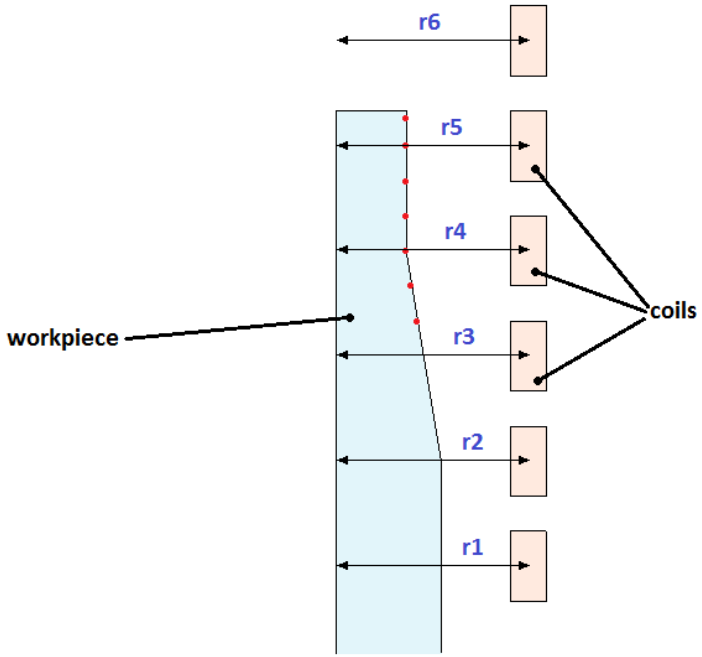
The geometry of the six coils is defined based on the parameters r1 to r6. r1 is the inner radius of the bottom coil, r2 is the inner radius of the next coil, etc. The points where the temperature is measured are shown in red. In OptiNet, a minimum and a maximum value for each variable is specified. OptiNet then searches within this range to find the optimum design



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OBJECTIVE FUNCTION - MINIMIZING THE RMS ERROR

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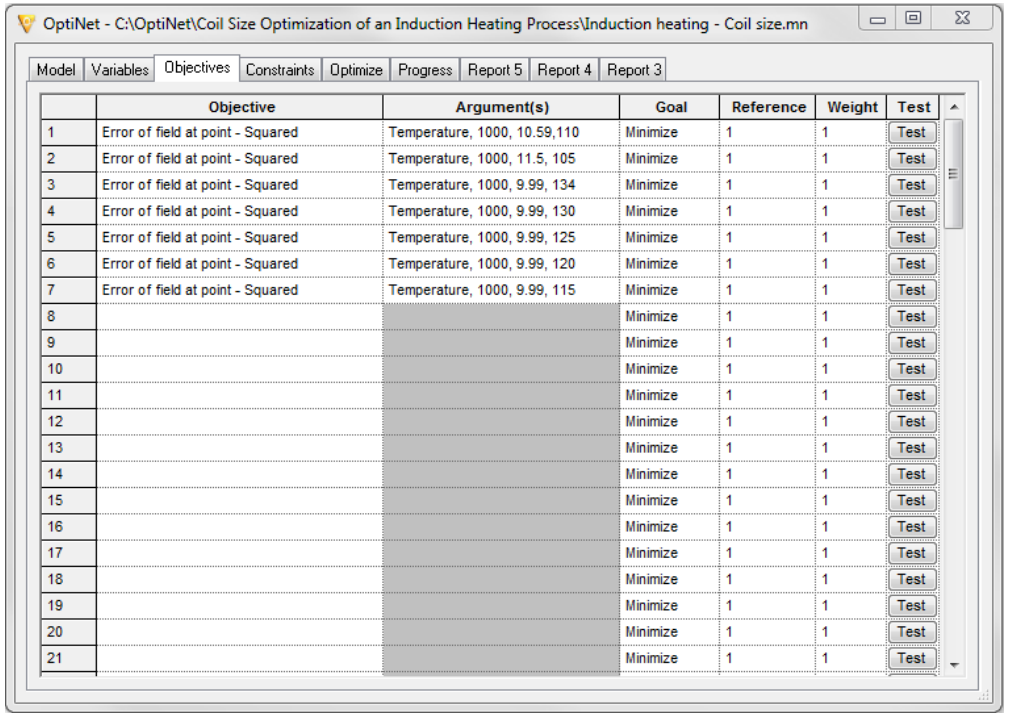
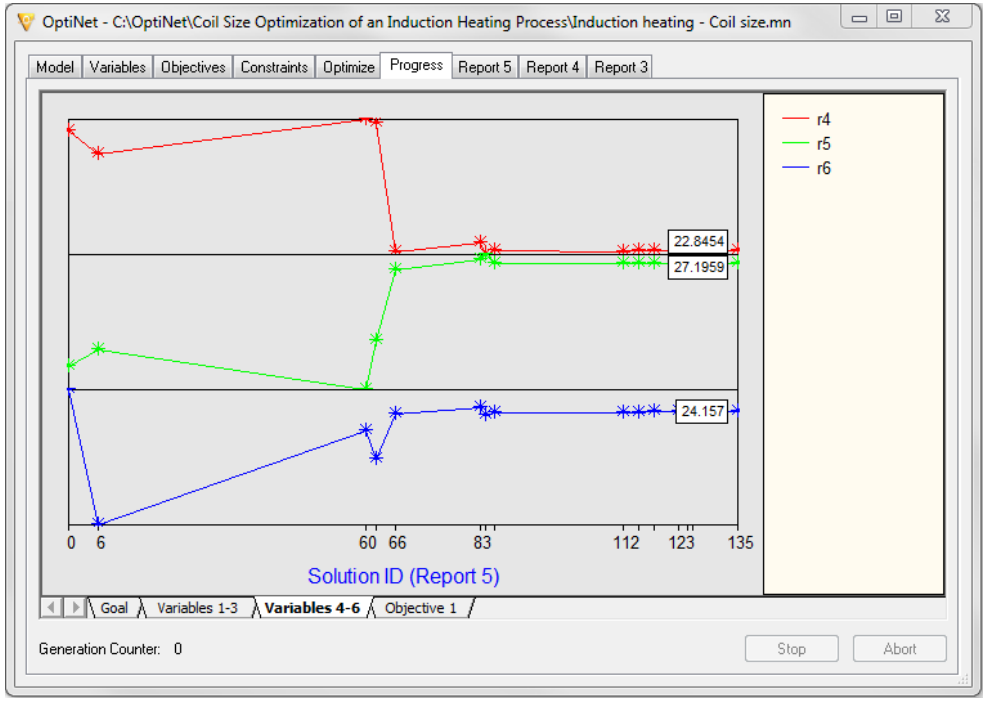


	Objective	Argument(s)	Goal	Reference	Weight	Test
1	Error of field at point - Squared	Temperature, 1000, 10.59,110	Minimize	1	1	Test
2	Error of field at point - Squared	Temperature, 1000, 11.5, 105	Minimize	1	1	Test
3	Error of field at point - Squared	Temperature, 1000, 9.99, 134	Minimize	1	1	Test
4	Error of field at point - Squared	Temperature, 1000, 9.99, 130	Minimize	1	1	Test
5	Error of field at point - Squared	Temperature, 1000, 9.99, 125	Minimize	1	1	Test
6	Error of field at point - Squared	Temperature, 1000, 9.99, 120	Minimize	1	1	Test
7	Error of field at point - Squared	Temperature, 1000, 9.99, 115	Minimize	1	1	Test
8			Minimize	1	1	Test
9			Minimize	1	1	Test
10			Minimize	1	1	Test
11			Minimize	1	1	Test
12			Minimize	1	1	Test
13			Minimize	1	1	Test
14			Minimize	1	1	Test
15			Minimize	1	1	Test
16			Minimize	1	1	Test
17			Minimize	1	1	Test
18			Minimize	1	1	Test
19			Minimize	1	1	Test
20			Minimize	1	1	Test
21			Minimize	1	1	Test

The objective is to obtain a temperature of 1000 degrees Celsius after 25 seconds at the surface in the upper section of the workpiece. The objective function is specified as the RMS error representing the deviation of the temperature values at several points from 1000 degrees. The goal is to minimize this RMS error. In OptiNet, it is possible to use any quantity obtained from ThermNet and use it as an objective. In this case, the temperature value at a particular point and time in the transient thermal solution is selected.

PROGRESS PAGE - (GOAL, VARIABLES, OBJECTIVES, AND CONSTRAINTS)



For every iteration of the optimization process, OptiNet updates and displays the changes (in the form of graphs) for the goal, variables, objectives, and constraints -- these graphs are displayed on the Progress page. In this example, each of the six variables' graphs is updated as OptiNet finds a new design.

REPORT GENERATOR - VIEW INDIVIDUAL DESIGNS

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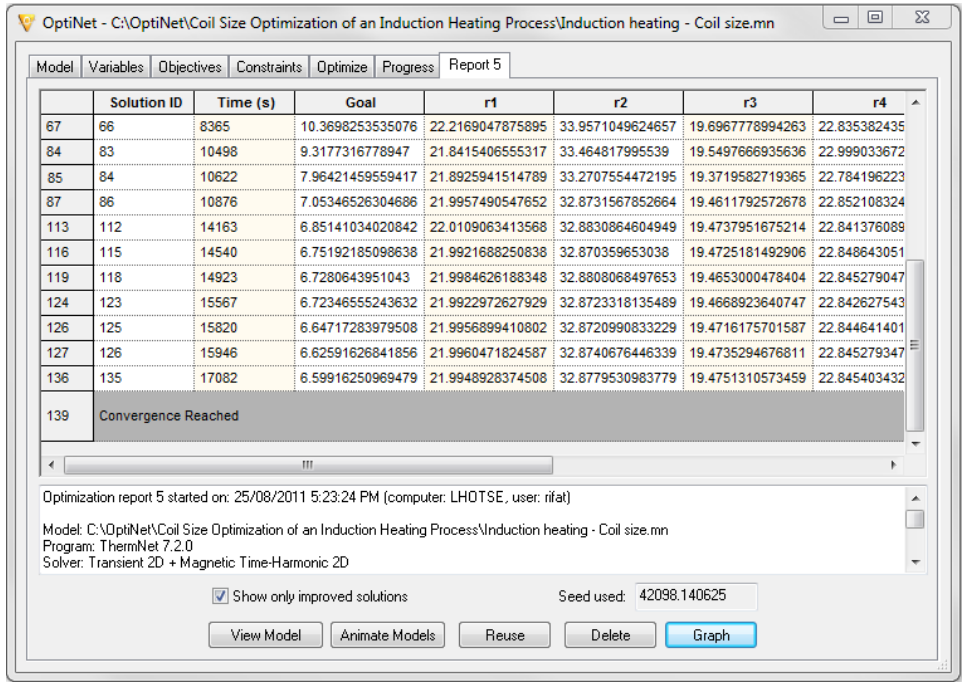
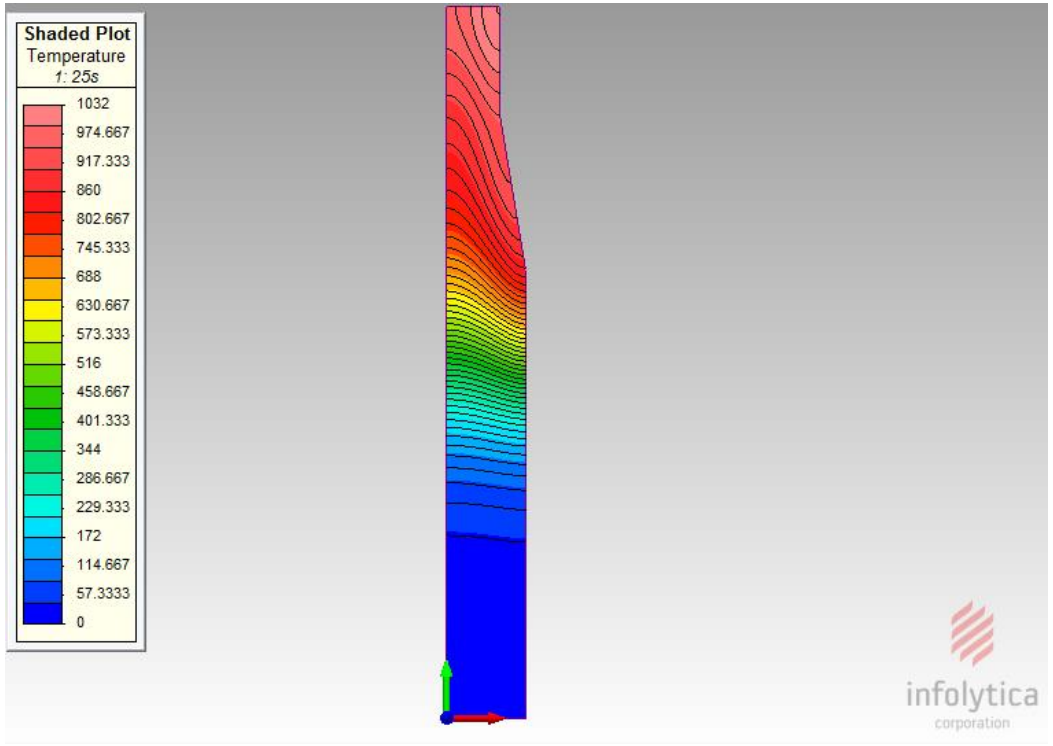
OptiNet produces a report for each optimization run. In this report, the designs that satisfy the constraints are shown in the order that they are improved. The user can view each design individually. The report also shows the time that it took to arrive at the improved design. The values of all the variables and the optimization function are displayed in this report for every iteration. The values of each parameter can be examined to determine the sensitivity of the design to that particular parameter.



INITIAL DESIGN - TEMPERATURE VARIATION



In the initial design that the user supplied to OptiNet, the temperature variation was obtained and is shown in this figure.

FINAL DESIGN - SIGNIFICANT REDUCTION IN TEMPERATURE VARIATION

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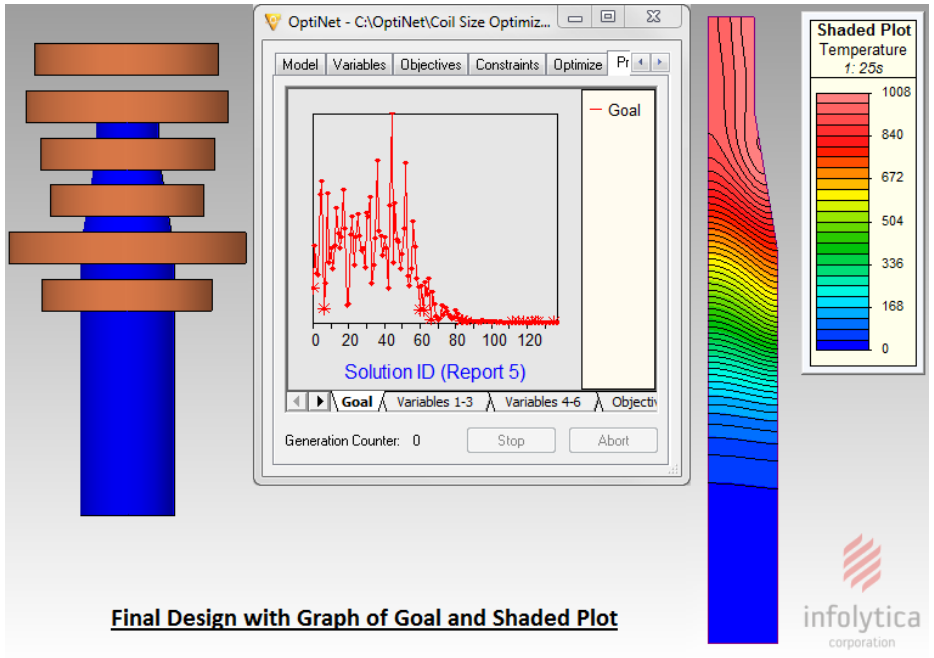
The final design that OptiNet produced is shown in this figure. As can be seen, the variation in temperature in the upper section of the workpiece has been reduced significantly. Of course, the user can examine previous improved designs. In this case, the variation in temperature had dropped significantly during the 80 first steps of the optimization process (see graph of goal) and during the remaining time OptiNet tried to find further improvement.



Final Design with Graph of Goal and Shaded Plot

In OptiNet, it is possible to stop the solution at different points, to examine the design and re-start the optimization process, for further improvements.