



# Optimization with QuickField



Vladimir Podnos,  
Director of Marketing and Support  
Advantages of QuickField  
for optimization problems

# QuickField Analysis Options

## Magnetic Suite

AC Magnetics

Transient + DC Magnetics

DC Magnetics

## Electric Suite

AC conduction + Electrostatics & DC conduction

Transient Electric + Electrostatics & DC conduction

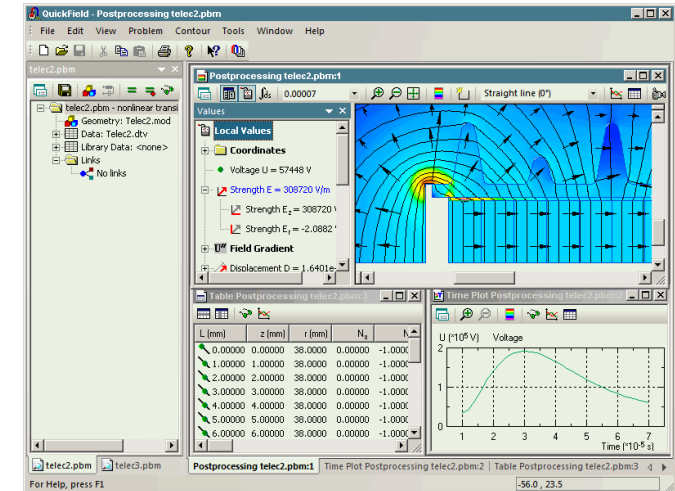
Electrostatics & DC conduction

## Thermostructural

Stress Analysis

Transient Heat transfer

Steady State Heat transfer

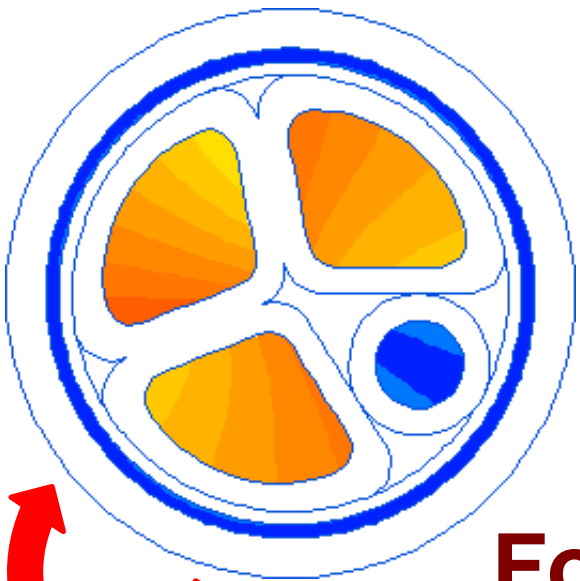




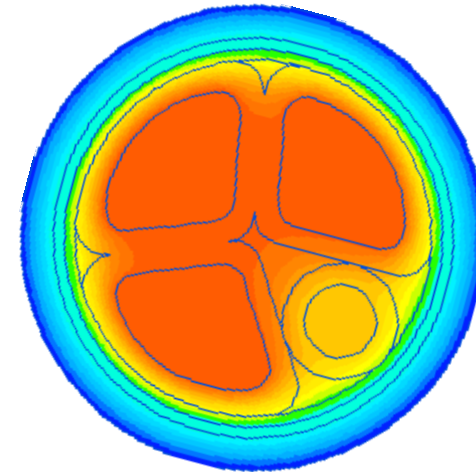
# MultiPhysics

Temperature  
Field

Electromagnetic fields

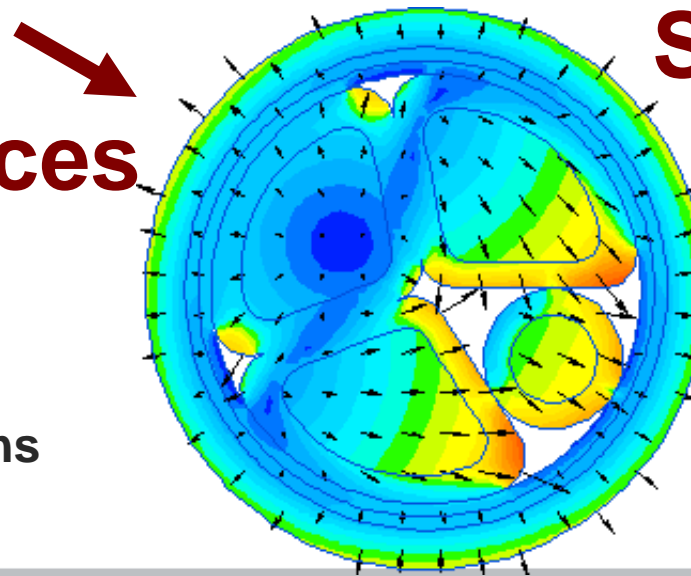


Magnetic state  
import



Forces

Stresses &  
Deformations

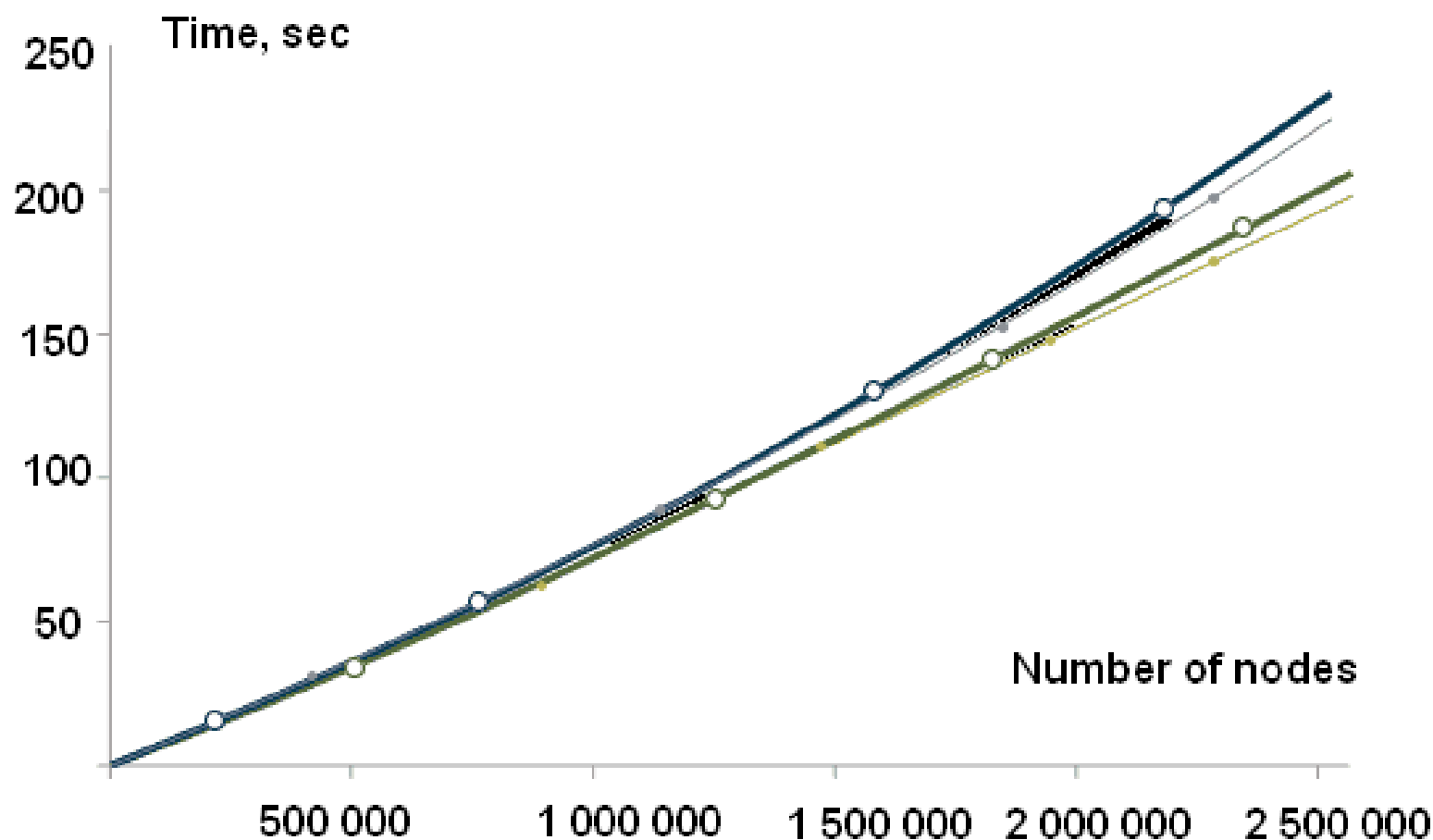


Thermal  
Stresses

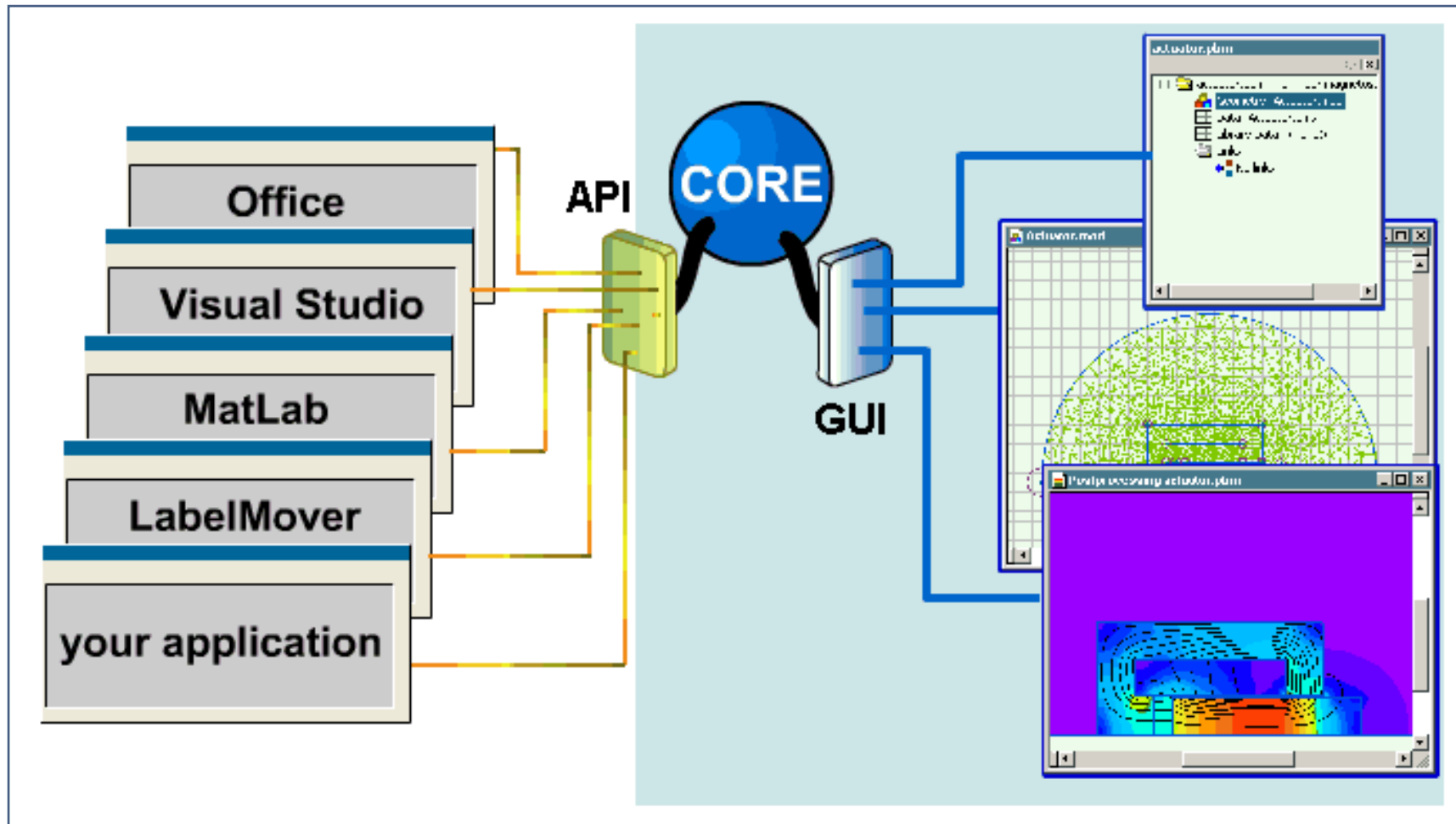


# QuickField solvers

Solution time for various sizes of finite element mesh



# Open object interface





# ActiveField API object model

**ActiveField™ help**

[Main QuickField Site](#)

[Free Downloads](#)

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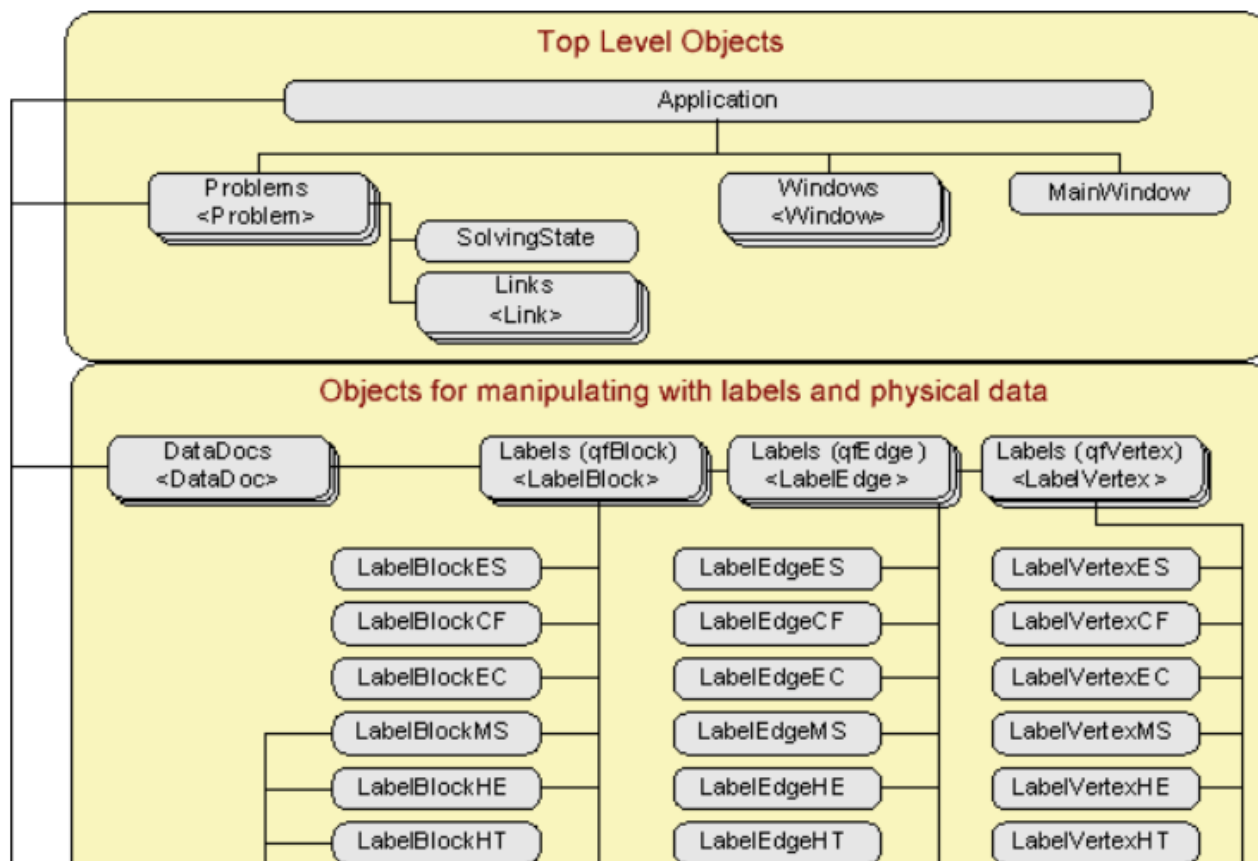
[ActiveField Technology](#)  
[Objects Overview](#)  
[Hierarchy Chart](#)  
[How to Start: Application Object](#)  
[How to work with Problems](#)  
[How to work with Model](#)  
[How to work with Data](#)  
[How to Analyze Results](#)

Objects

Properties

Methods

## QuickField Object Model



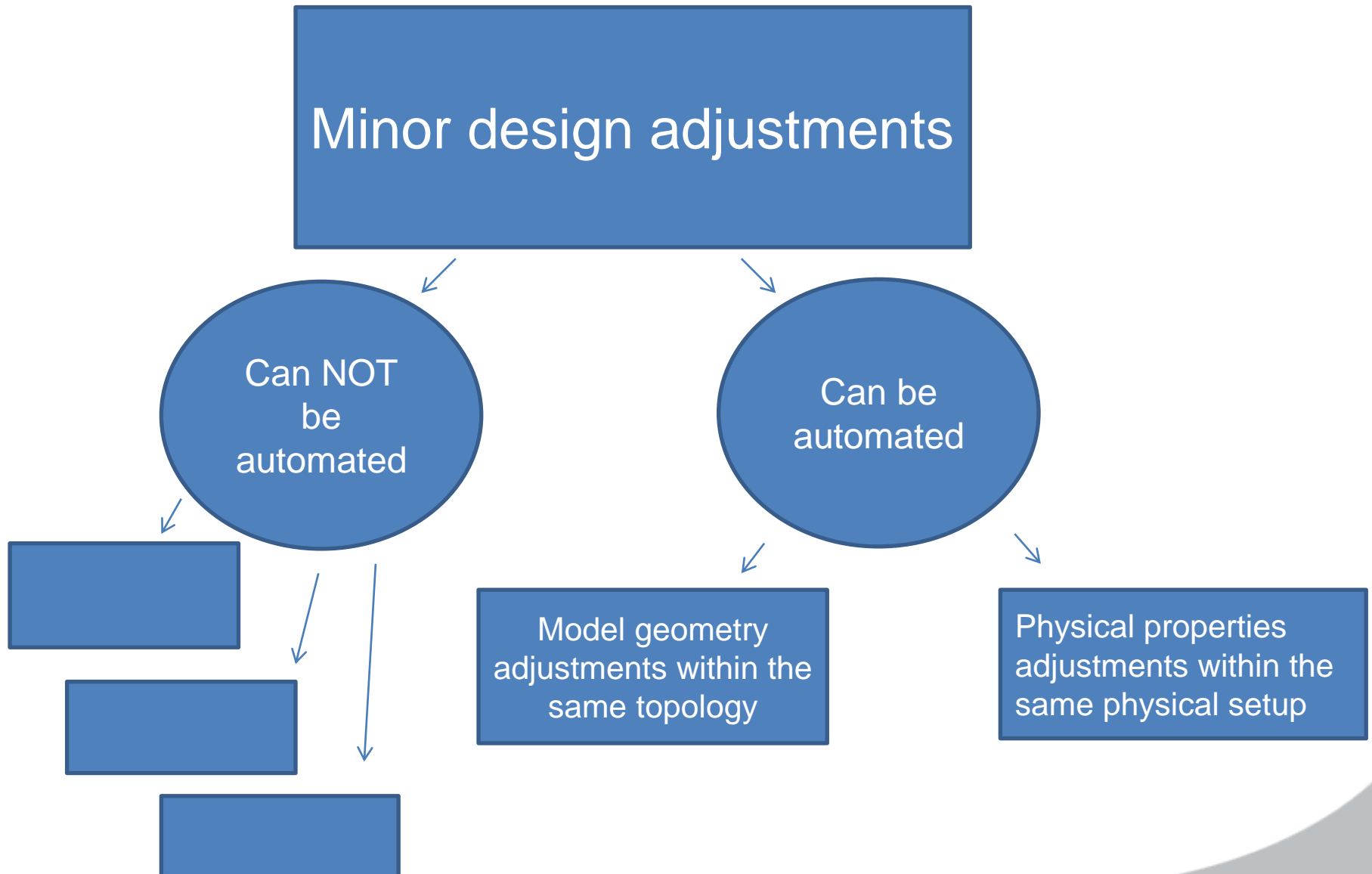


# Engineering design optimization

- Major design modifications performed by experienced engineer or
- Minor design adjustments due to slightly different operating conditions, material change, technological limitations, adjusted design specifications etc.



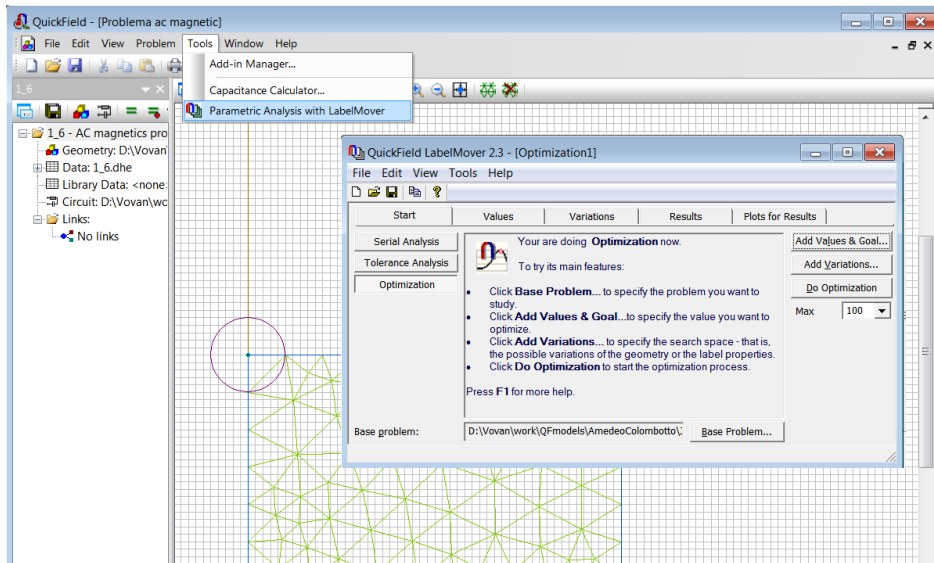
# Engineering design optimization



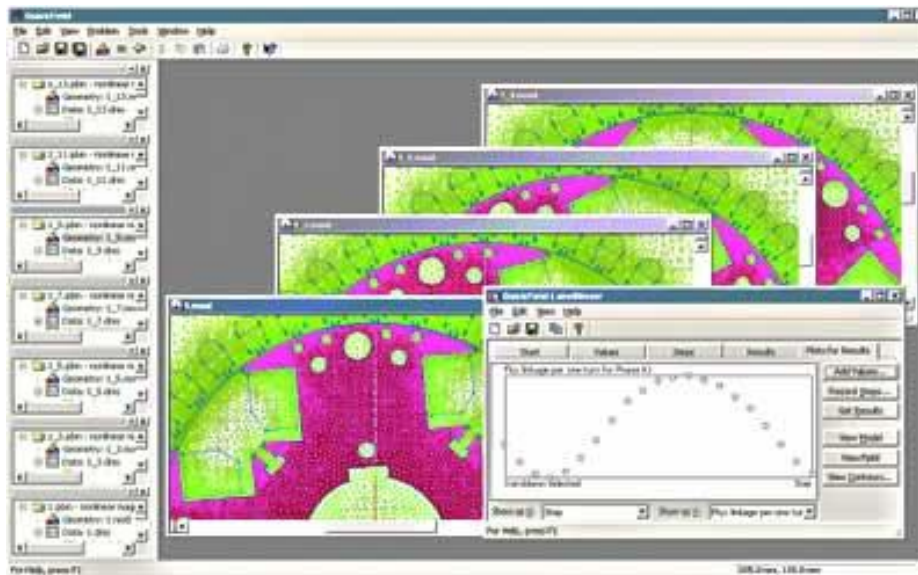




# Parametric analysis with LabelMover




- Serial analysis
- Tolerance analysis
- Optimization
  - Built-in algorithms
  - Externally connected algorithms







# LabelMover optimization benchmarks

<http://www.quickfield.com/advanced/optimization-benchmarks.htm>

 **QuickField** *A new approach to field modelling*

Language: 

Search 

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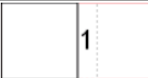
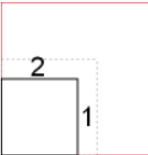
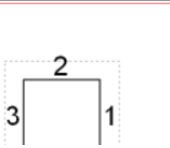
CONTACTS



[Main](#) > [Application](#) > [Sample problems](#)

**LabelMover optimization benchmark**

Here are [LabelMover](#) optimization benchmarks.

| Task  | Theory | QuickField | %     |
|---|--------|------------|-------|
| <br><a href="#">linear1</a> . Move square's right edge to the right in order to get the maximal cross-section area. The movement range is 0..1.<br>The optimized value is linearly dependent upon the optimization parameter.  | 2      | 1.9981     | 0.1%  |
| <br><a href="#">linear2</a> . Move square's right and top edges right and up correspondingly in order to get the maximal cross-section area. The movement range for each edge is 0..1.<br>The optimized value is linearly dependent upon two optimization parameters. | 4      | 3.9836     | 0.41% |
| <br><a href="#">linear3</a> . Move square's 3 edges (right, left and top) in order to get the maximal cross-section area. The movement range for each edge is 0..1.<br>The optimized value is linearly dependent upon three optimization parameters.                  | 6      | 5.9674     | 0.54% |

Industrial

Educational

Scientific

Sample problems

Examples gallery

Step-by-step tutorials

Verification examples

Programming examples

Distributive examples

Success stories

Customers

# QuickField Difference





# Optimization with QuickField

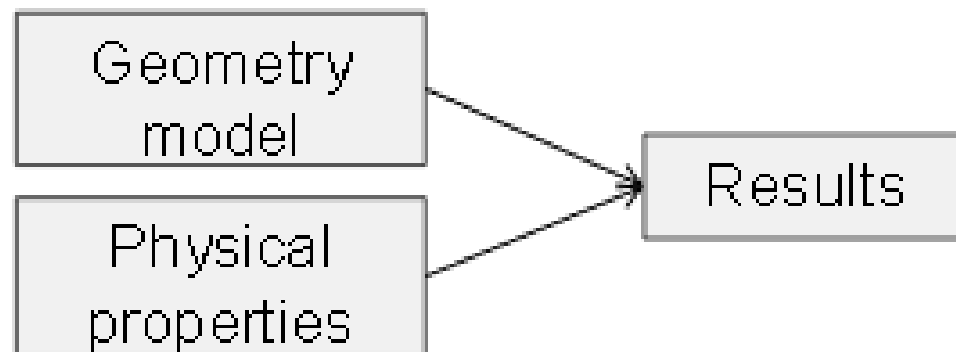


Sergey Ionin,  
Support engineer  
Optimization in QuickField

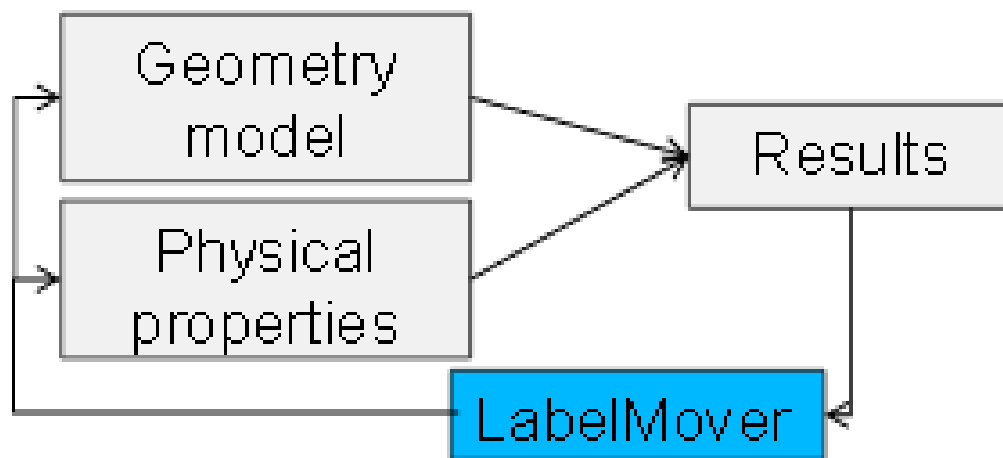


# Problems in QuickField

Direct problem



Inverse problem  
(optimization or  
identification)



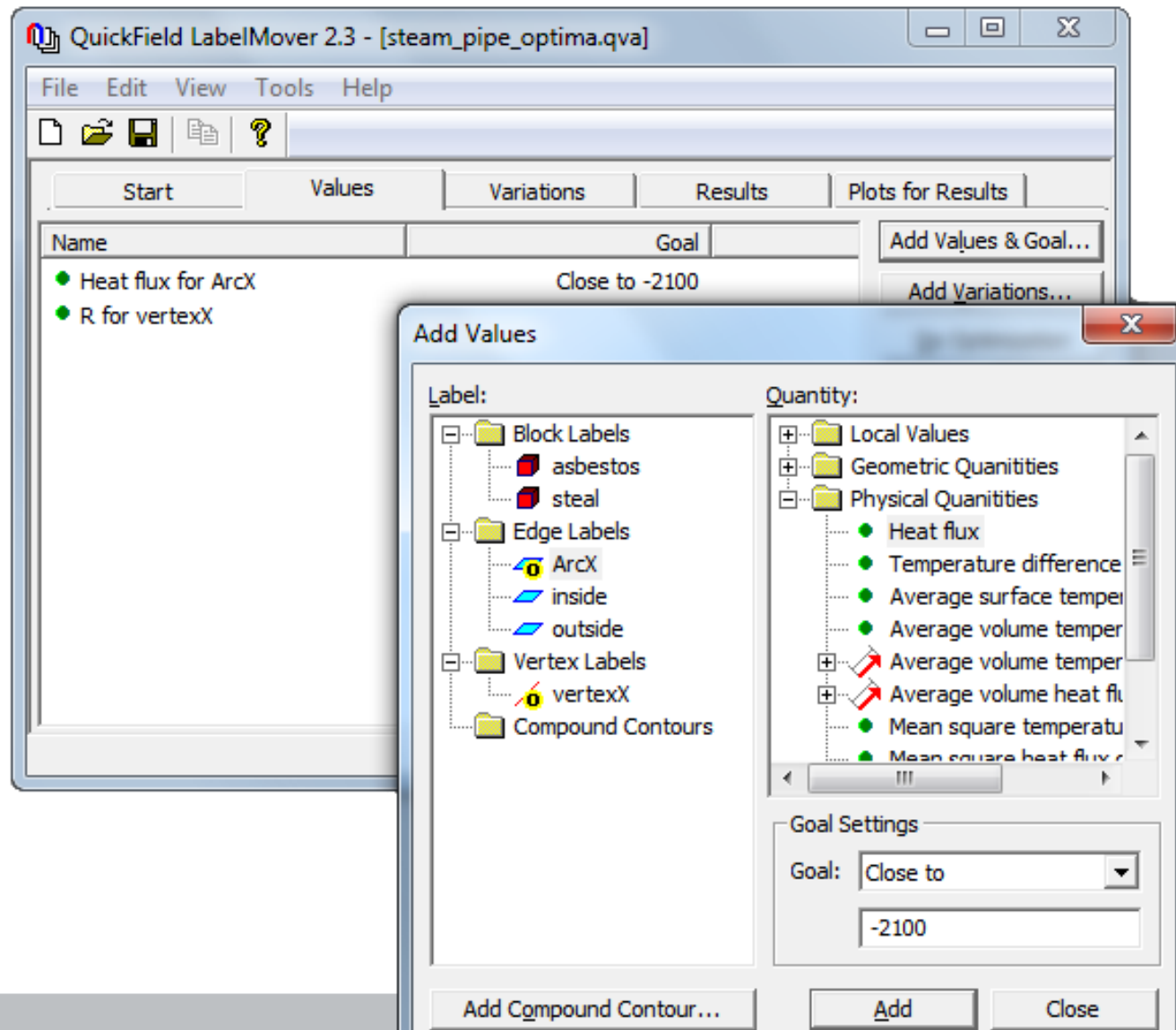


# Inverse problems

- **Design**
- **Identification**
- **Diagnostics**
- ...

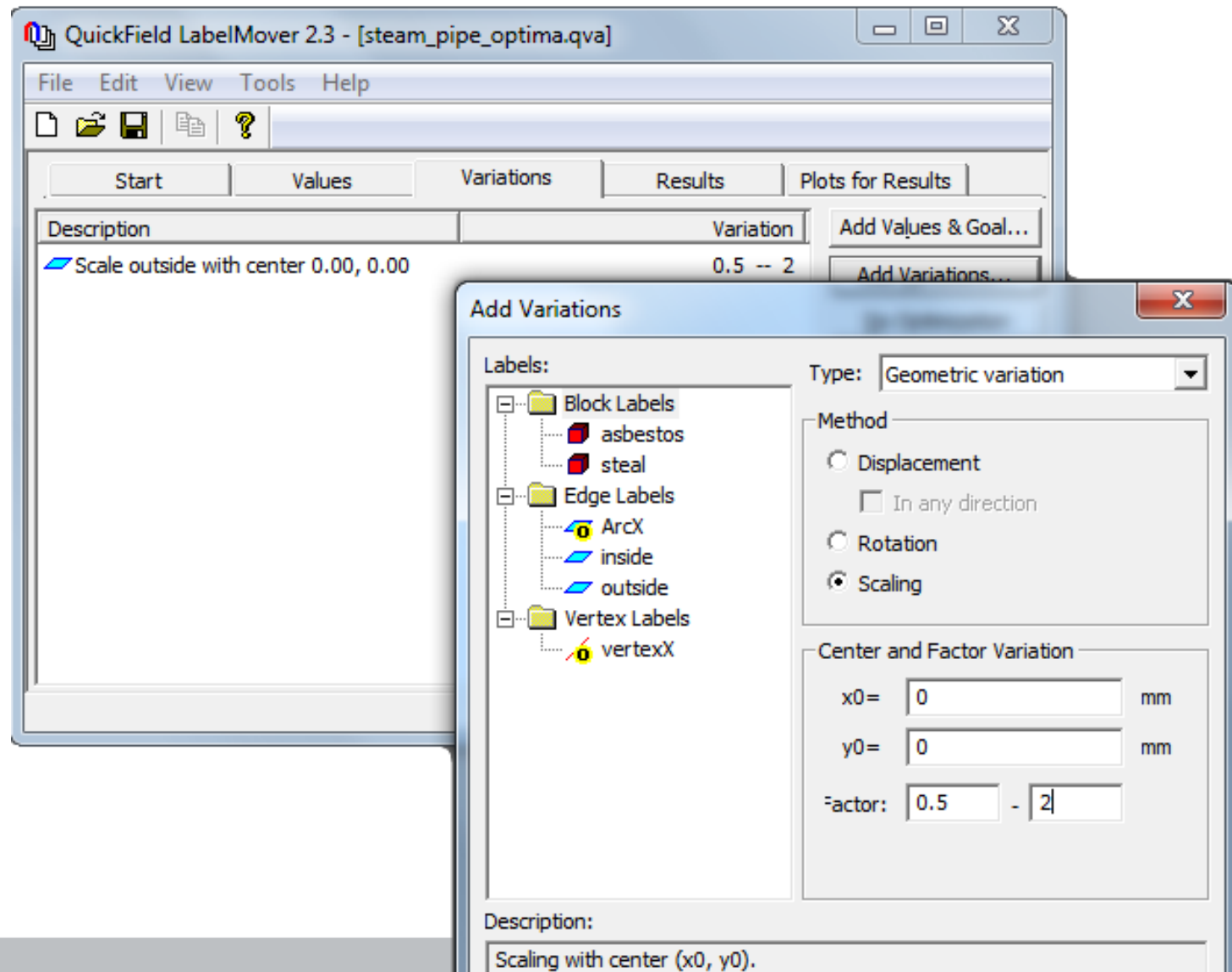
# Optimization in LabelMover

## 1. Set values and goal



# Optimization in LabelMover

## 2.Set variations





# Optimization in LabelMover

## 3. Get results

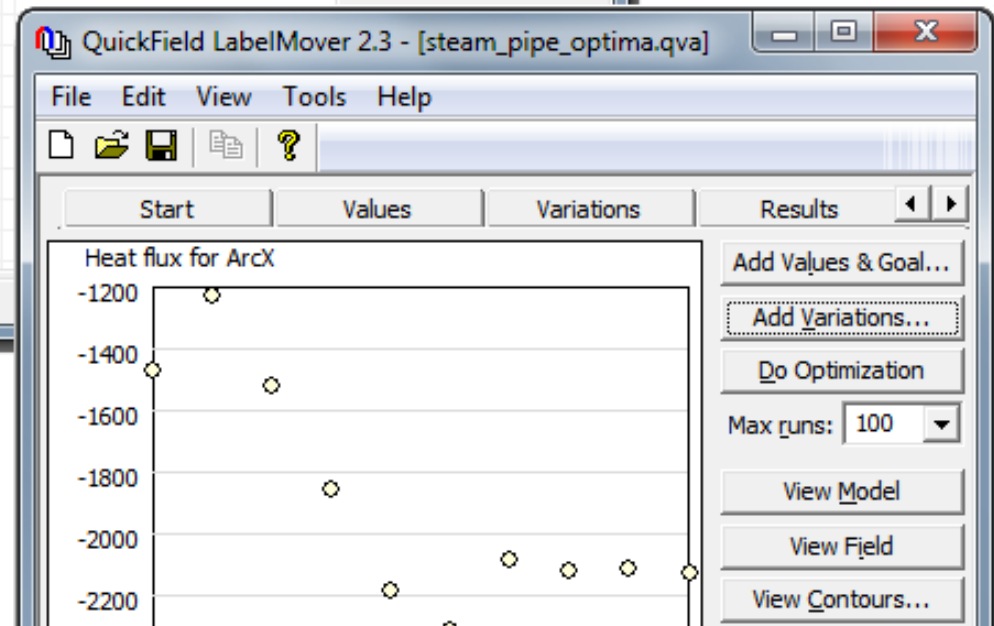
QuickField LabelMover 2.3 - [steam\_pipe\_optima.qva]

File Edit View Tools Help

Start Values Variations Results Plots for Results

| Step | Scale out... | Heat flux... | R for ver... |
|------|--------------|--------------|--------------|
| 0    | 1            | -1466        | 150          |
| 1    | 1.25         | -1223.3      | 187.5        |
| 2    | 0.96353      | -1514.4      | 144.53       |
| 3    | 0.78647      | -1839.2      | 117.97       |
| 4    | 0.67705      | -2166.2      | 101.56       |
| 5    | 0.64602      | -2288.4      | 96.904       |
| 6    | 0.706        | -2065.3      | 105.9        |
| 7    | 0.69522      | -2102.3      | 104.28       |
| 8    | 0.69672      | -2097.3      | 104.51       |
| 9    | 0.69372      | -2107.2      | 104.06       |

Add Values & Goal...  
Add Variations...  
Do Optimization  
Max runs: 100  
View Model





# Optimization using external Monte-Carlo algorithm



VBA (Visual Basic for Applications) script will do random variations controlling solving of problems in QuickField



# Optimization using external Monte-Carlo algorithm

Variation of parameter will be calculated by the formula:

$$V = V\_down + (V\_up - V\_down) \cdot Rnd(1)$$

$V\_down$  – lower limit for variation

$V\_up$  - upper limit for variation

$Rnd(1)$  – random value in range of (0-1)



# VBA code for Monte-Carlo

Sub Optimize()

```
' Declaration of values
Dim my_qlm As QLM.SimpleInterface
Set my_qlm = CreateObject("qlm.SimpleInterface")
Dim variation_0 As Double 'variation
Dim result As Double ' result
Dim result_intermediate As Double ' intermediate result
Dim N As Double 'number of iterations
Dim N_better_res As Double 'number of another better result
Dim limit_0_down As Double ' lower limit of variation
Dim limit_0_up As Double ' upper limit of variation
Dim goal As Double ' optimization aim
Dim count As Integer ' counter
```

Declaration of values

```
'Reading of values from the spreadsheet
limit_0_down = Worksheets("UI").Cells(7, 2).Value
limit_0_up = Worksheets("UI").Cells(8, 2).Value
N = Worksheets("UI").Cells(9, 2).Value
goal = Worksheets("UI").Cells(10, 2).Value
```

Reading of values from the spreadsheet

```
' Initialization of values
variation_0 = limit_0_down + (limit_0_up - limit_0_down) * Rnd(1)
my_qlm.SetVariation 0, variation_0
my_qlm.Solve
result = my_qlm.GetResult(0)
N_better_res = 1
Worksheets("UI").Cells(6, 4).Value = 1
Worksheets("UI").Cells(6, 5).Value = result
```

Initialization of values

```
' Cycle
For count = 2 To N
variation_0 = limit_0_down + (limit_0_up - limit_0_down) * Rnd(1)
my_qlm.SetVariation 0, variation_0
my_qlm.Solve
result_intermediate = my_qlm.GetResult(0)
If Abs(result_intermediate - goal) < Abs(result - goal) Then
result = result_intermediate
N_better_res = N_better_res + 1
Worksheets("UI").Cells(6 + (N_better_res - 1), 4).Value = count
Worksheets("UI").Cells(6 + (N_better_res - 1), 5).Value = result
End If
Next count
```

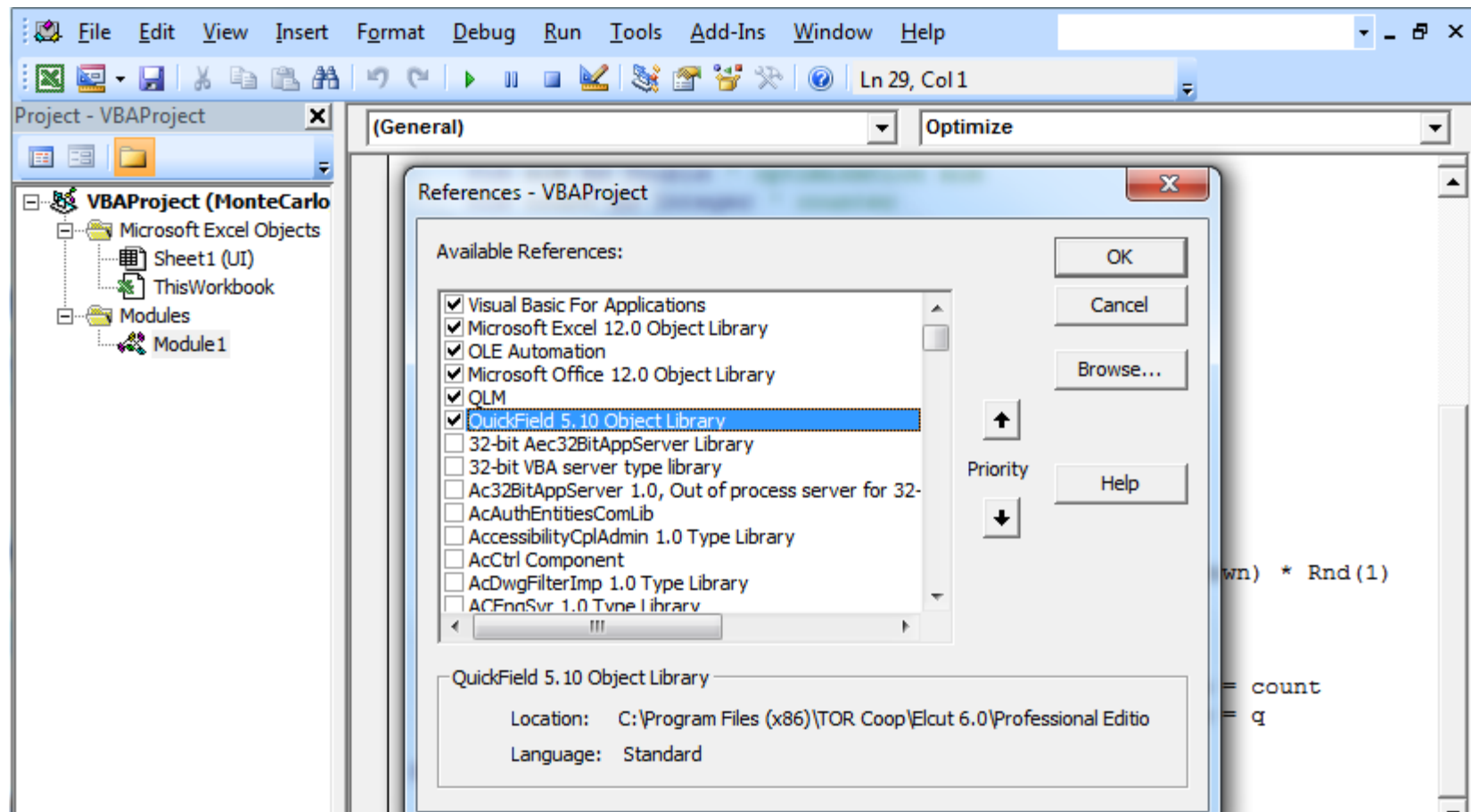
Cycle

End Sub



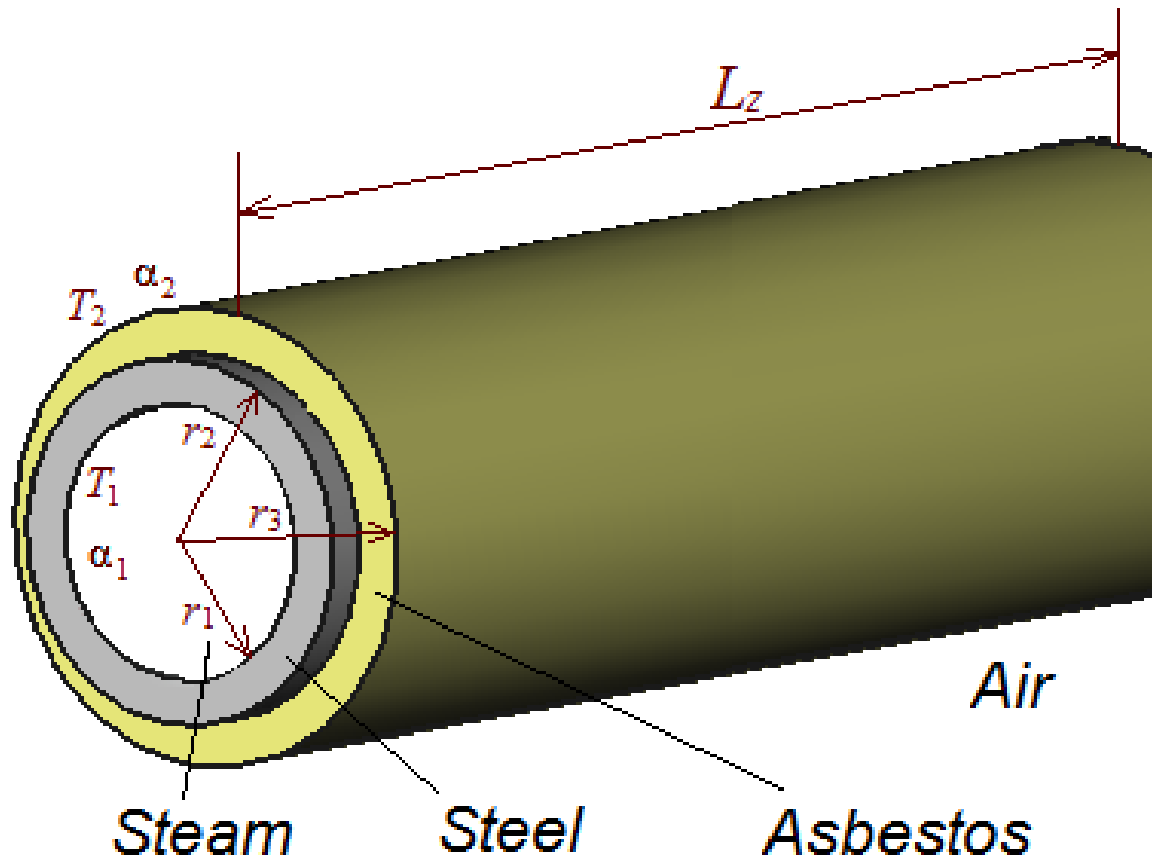
# Preparations in VBA

## Tools > References





# Heat Transfer problem: calculation of required insulation thickness



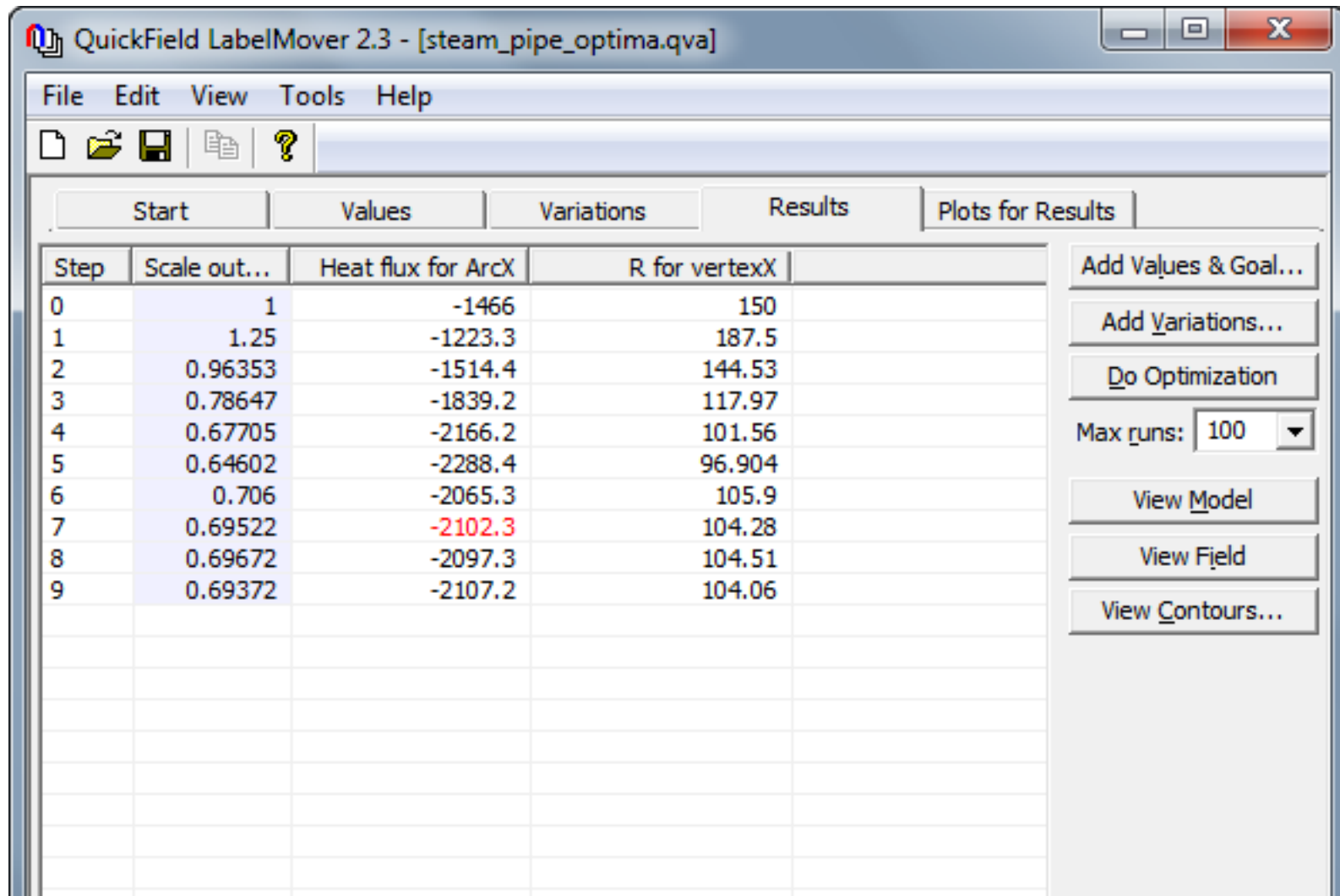
## Task:

Calculate thickness of the steam pipe insulation to provide prescribed value of heat flux of 2100 W

## Exact solution:

$$r_3 - r_2 = 25 \text{ mm}$$

# Solving using LabelMover



QuickField LabelMover 2.3 - [steam\_pipe\_optima.qva]

File Edit View Tools Help

Start Values Variations Results Plots for Results

| Step | Scale out... | Heat flux for ArcX | R. for vertexX |
|------|--------------|--------------------|----------------|
| 0    | 1            | -1466              | 150            |
| 1    | 1.25         | -1223.3            | 187.5          |
| 2    | 0.96353      | -1514.4            | 144.53         |
| 3    | 0.78647      | -1839.2            | 117.97         |
| 4    | 0.67705      | -2166.2            | 101.56         |
| 5    | 0.64602      | -2288.4            | 96.904         |
| 6    | 0.706        | -2065.3            | 105.9          |
| 7    | 0.69522      | -2102.3            | 104.28         |
| 8    | 0.69672      | -2097.3            | 104.51         |
| 9    | 0.69372      | -2107.2            | 104.06         |

Add Values & Goal...  
Add Variations...  
Do Optimization  
Max runs: 100  
View Model  
View Field  
View Contours...



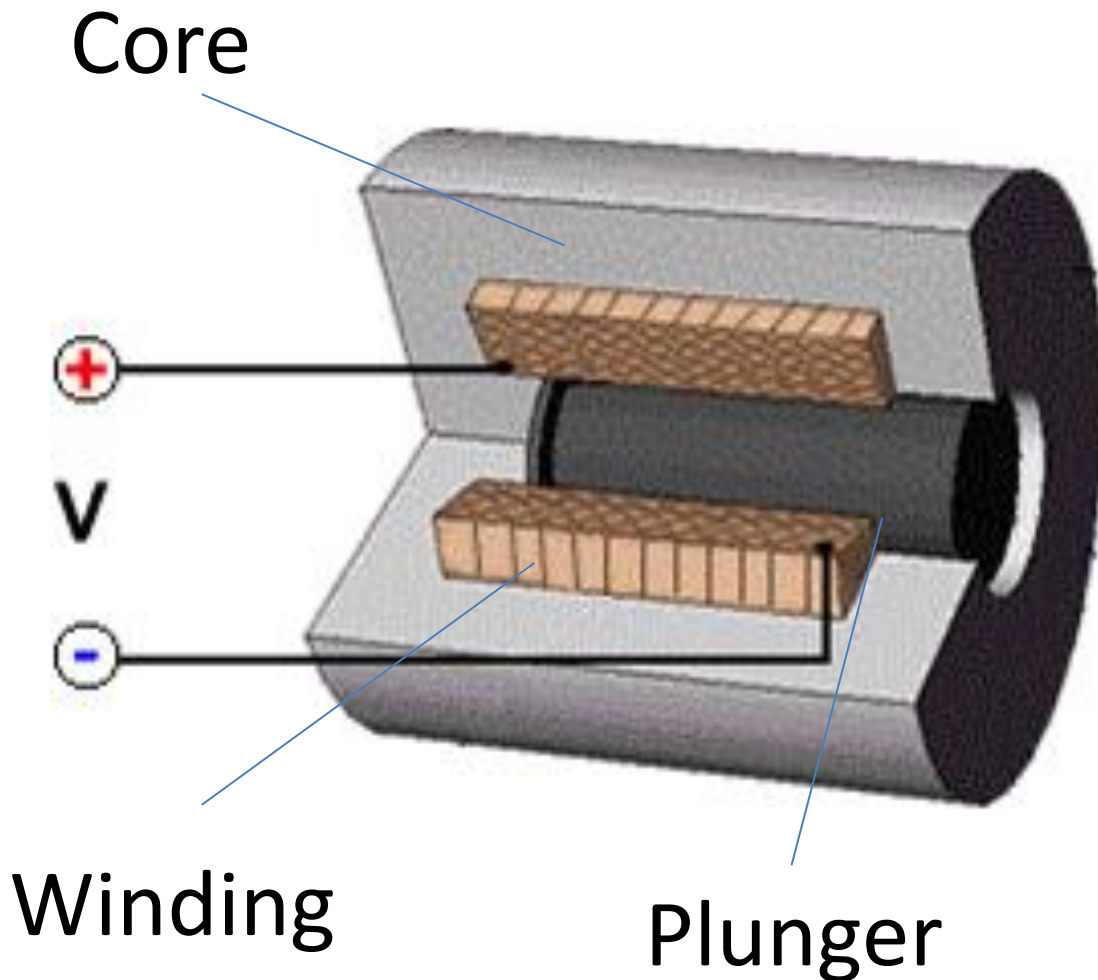
# Solving using VBA

|    | A   | B         | C | D | E               | F               |
|----|---|-----------|---|---|-----------------|-----------------|
| 1  | <b>Monte-Carlo approach in Optimization</b>   |           |   |   |                 |                 |
| 2  | This script will work with opened QuickField problem and LabelMover optimization file |           |   |   |                 |                 |
| 3  |   |           |   |   |                 |                 |
| 4  | Limits for variation of the value   |           |   |   | Results         |                 |
| 5  |   |           |   |   | Ne of iteration | function value  |
| 6  |   |           |   |   |                 | parameter value |
| 7  |   |           |   |   | 1               | -971,905        |
| 8  |   |           |   |   | 2               | -974,577        |
| 9  | Lower limit   | 5,00E-01  |   |   | 3               | -1134,69        |
| 10 | Upper limit   | 2,00E+00  |   |   | 4               | -1134,69        |
| 11 | Number of iterations  | 1,00E+01  |   |   | 5               | -1134,69        |
| 12 | Goal  | -2,10E+03 |   |   | 6               | -1720,71        |
| 13 |   |           |   |   | 7               | -1720,71        |
| 14 |   |           |   |   | 8               | -1720,71        |
| 15 |   |           |   |   | 9               | -1720,71        |
| 16 |   |           |   |   | 10              | -1720,71        |
| 17 |   |           |   |   |                 |                 |





# Magnetic problem: calculation of required core cross-section of the drive



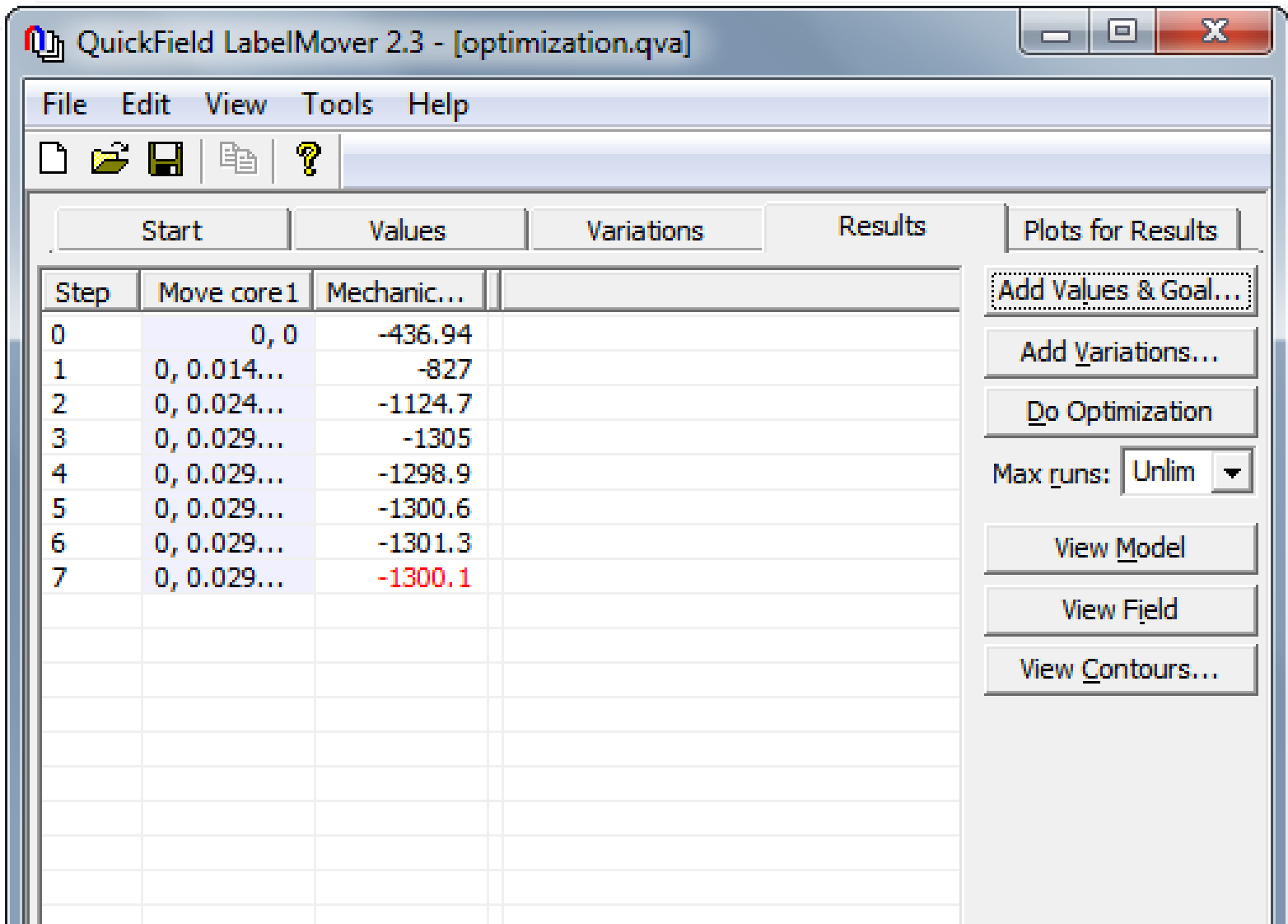
## Task:

Calculate required thickness of the core to provide force on the plunger of 1300 N.

## Exact solution:

10.4 mm

# Solving using LabelMover



The screenshot displays the QuickField LabelMover 2.3 application window, titled "QuickField LabelMover 2.3 - [optimization.qva]". The interface includes a menu bar (File, Edit, View, Tools, Help) and a toolbar with icons for file operations and help. The main workspace is divided into several sections:

- Start**: A tab for defining the initial state.
- Values**: A tab for defining the values of the variables.
- Variations**: A tab for defining the variations of the variables.
- Results**: A tab for displaying the results of the optimization process.
- Plots for Results**: A tab for displaying plots of the results.

The **Results** tab is currently active, showing a table with the following data:

| Step | Move core1  | Mechanic... |
|------|-------------|-------------|
| 0    | 0, 0        | -436.94     |
| 1    | 0, 0.014... | -827        |
| 2    | 0, 0.024... | -1124.7     |
| 3    | 0, 0.029... | -1305       |
| 4    | 0, 0.029... | -1298.9     |
| 5    | 0, 0.029... | -1300.6     |
| 6    | 0, 0.029... | -1301.3     |
| 7    | 0, 0.029... | -1300.1     |

On the right side of the interface, there are several buttons and controls for managing the optimization process:

- Add Values & Goal...**: A button to add new values and goals.
- Add Variations...**: A button to add new variations.
- Do Optimization**: A button to start the optimization process.
- Max runs:** A dropdown menu set to "Unlim".
- View Model**: A button to view the model.
- View Field**: A button to view the field.
- View Contours...**: A button to view the contours.

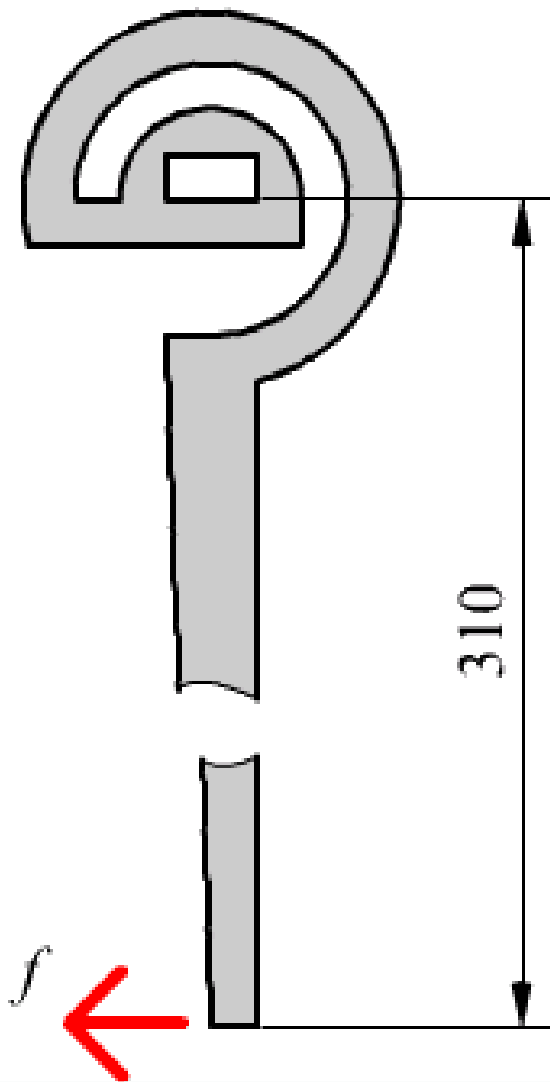


# Solving using VBA

|    | A   | B         | C | D               | E              | F               |
|----|---|-----------|---|-----------------|----------------|-----------------|
| 1  | <b>Monte-Carlo approach in Optimization</b>   |           |   |                 |                |                 |
| 2  | This script will work with opened QuickField problem and LabelMover optimization file |           |   |                 |                |                 |
| 3  |   |           |   |                 |                |                 |
| 4  | Limits for variation of the value   |           |   |                 |                |                 |
| 5  |   |           |   | Results         |                |                 |
| 6  |   |           |   | No of iteration | function value | parameter value |
| 7  |   |           |   | 1               | -1237,57       | 0,027516353     |
| 8  | Lower limit   | 0,00E+00  |   | 2               | -1237,57       | 0,027516353     |
| 9  | Upper limit   | 3,90E-02  |   | 3               | -1237,57       | 0,027516353     |
| 10 | Number of iterations  | 1,00E+01  |   | 4               | -1237,57       | 0,027516353     |
| 11 | Goal  | -1,30E+03 |   | 5               | -1237,57       | 0,027516353     |
| 12 |   |           |   | 6               | -1314,09       | 0,030214864     |
| 13 |   |           |   | 7               | -1314,09       | 0,030214864     |
| 14 |   |           |   | 8               | -1302,73       | 0,02966822      |
| 15 |   |           |   | 9               | -1302,73       | 0,02966822      |
| 16 |   |           |   | 10              | -1302,73       | 0,02966822      |
| 17 |   |           |   |                 |                |                 |



# Mechanical problem: calculation of allowable force for dynamo wrench



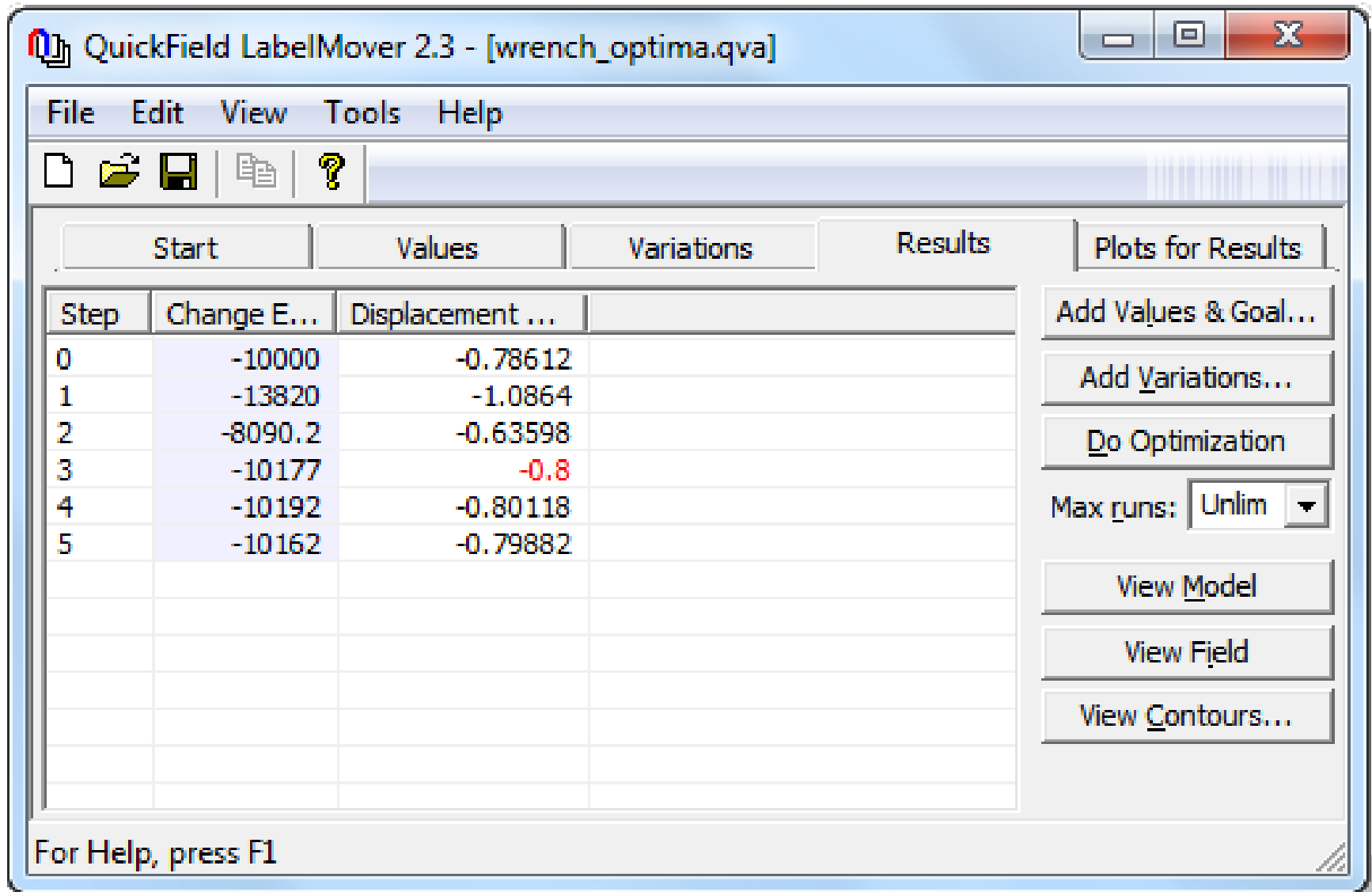
## Task:

Determine maximal force which will not cause unallowable deformations

## Exact solution:

$$f = 10177 \text{ N}$$

# Solving using LabelMover



QuickField LabelMover 2.3 - [wrench\_optima.qva]

File Edit View Tools Help

Start Values Variations Results Plots for Results

| Step | Change E... | Displacement ... |  |
|------|-------------|------------------|--|
| 0    | -10000      | -0.78612         |  |
| 1    | -13820      | -1.0864          |  |
| 2    | -8090.2     | -0.63598         |  |
| 3    | -10177      | -0.8             |  |
| 4    | -10192      | -0.80118         |  |
| 5    | -10162      | -0.79882         |  |
|      |             |                  |  |
|      |             |                  |  |
|      |             |                  |  |
|      |             |                  |  |
|      |             |                  |  |
|      |             |                  |  |
|      |             |                  |  |

Add Values & Goal...

Add Variations...

Do Optimization

Max runs: Unlim

View Model

View Field

View Contours...

For Help, press F1



# Solving using VBA

|    | A   | B         | C | D               | E              | F               |
|----|---|-----------|---|-----------------|----------------|-----------------|
| 1  | <b>Monte-Carlo approach in Optimization</b>   |           |   |                 |                |                 |
| 2  | This script will work with opened QuickField problem and LabelMover optimization file |           |   |                 |                |                 |
| 3  |   |           |   |                 |                |                 |
| 4  | Limits for variation of the value   |           |   |                 |                |                 |
| 5  |   |           |   | Results         |                |                 |
| 6  |   |           |   | Nº of iteration | function value | parameter value |
| 7  |   |           |   | 1               | -0,95332       | -12126,9736     |
| 8  | Lower limit   | -2,00E+04 |   | 2               | -0,66768       | -8493,32511     |
| 9  | Upper limit   | -5,00E+03 |   | 3               | -0,66768       | -8493,32511     |
| 10 | Number of iterations  | 1,00E+01  |   | 4               | -0,87362       | -11113,1263     |
| 11 | Goal  | -8,00E-01 |   | 5               | -0,87362       | -11113,1263     |
| 12 |   |           |   | 6               | -0,87362       | -11113,1263     |
| 13 |   |           |   | 7               | -0,83797       | -10659,5495     |
| 14 |   |           |   | 8               | -0,80834       | -10282,6822     |
| 15 |   |           |   | 9               | -0,80834       | -10282,6822     |
| 16 |   |           |   | 10              | -0,80834       | -10282,6822     |
| 17 |   |           |   |                 |                |                 |