General Statistical Design of Experimental Problem for Harmonics

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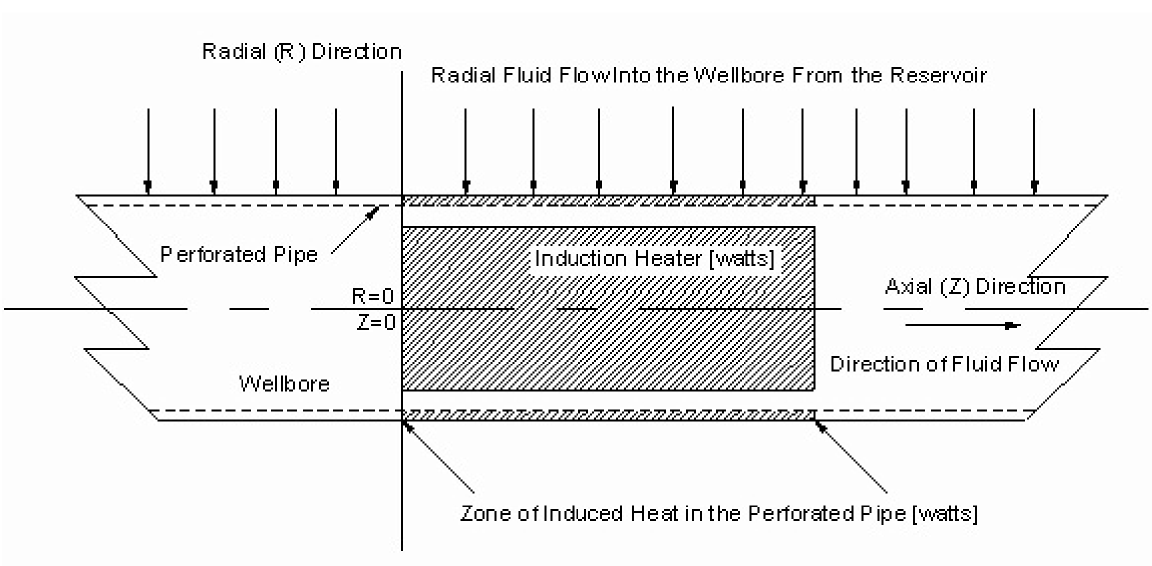
This practical problem falls into the area of Boundary Value Problems and Mathematical Physics. It is a practical problem in the recovery of petroleum fluids from an oil reservoir using electrical energy. The geometry of the problem best fits the cylindrical coordinate system, as shown in the Figure.

Some assumptions:

1. All fluid flow is laminar and incompressible,
2. Field symmetry in the angular direction,
3. The pipe is made from steel and has a thermal conductivity of $50.0[Wm^{-1o}C^{-1}]i$
4. The inductor heater is made from a material that has a thermal conductivity of $1.8[Wm^{-1o}C^{-1}]$
5. Radial fluid velocity is initially uniform and radial into the wellbore. A non-linearity is introduced into the problem if the radial velocity is a function of temperature as follows (the velocity increases as the temperature increases):
6. The zone of induced heat in the pipe extends from one end of the induction heater to the other.
7. The direction of flow is with increasing z.
8. The power in the zone of induced heat in the perforated pipe is equal to ten times the power in the induction tool.
9. The wellbore is filled with the fluids that flow from the reservoir.
10. The fluids and reservoir have a thermal conductivity of $0.9[Wm^{-1o}C^{-1}]$

Other physical properties will be provided at the conference. The exercise is to solve the transient or steady state temperature distribution in the axial and radial direction, and consequently determine the increase in flow velocity along the length of the wellbore.

The definition of the boundary conditions, the symmetry for the problem, definition of regions, and dimensional coupling of the physical space are probably the most important issues to solving the problem. The initial approach would be to define the governing partial differential equations in each region. Transform these equations into Laplace Space. The transformed partial differential equations are now ordinary differential equations and can be solved directly (from the boundary values). Finally, use a numerical inversion algorithm to invert the Laplace Space into the time domain (for example the Stehfest algorithm).


Radial (R) Direction
Radial Fluid Flow Into the Wellbore From the Reservoir
Perforated Pipe
Induction Heater [watts]
R=0
Z=0
Axial (Z) Direction
Direction of Fluid Flow
Wellbore
Zone of Induced Heat in the Perforated Pipe [watts]