ME 409

LAB 8 : Solution of thermal, species and flow during phase change

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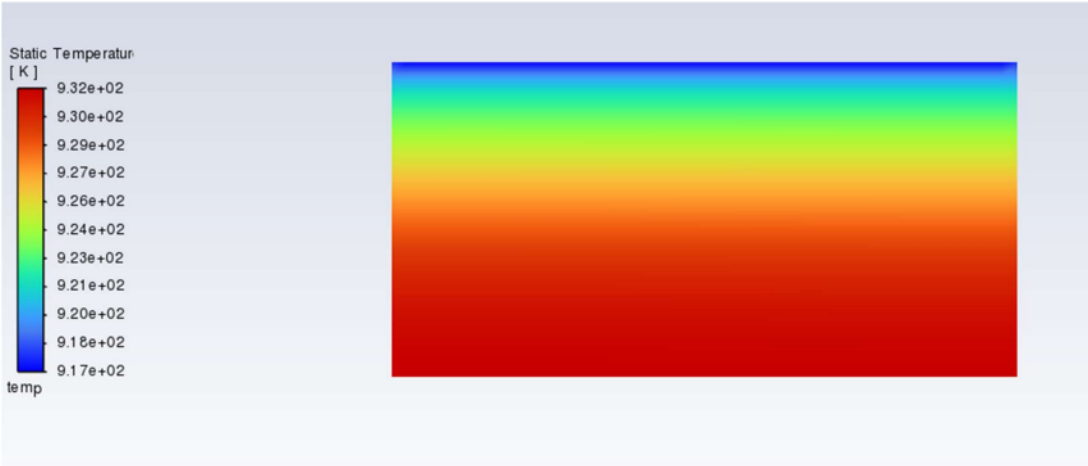
1. **Problem definition - What are we solving, and what are the conditions?**
   Solute rejection occurs during the solidification of Aluminium-copper system, and we are asked to analyse it using fluent ANSYS.

2. **Solution methodology - discretized domain (mesh) and properties used**
   - A 2D domain of dimension 10mm×15mm is considered.
   - We perform the mashing. The domain is discretized by using quadrilateral elements of equal size and then giving names to our edges/walls.
   - We will use transient time for analysis
   - Gravity will be -9.8 m/s^2.
   - Laminar flow conditions are used.
   - The energy equation is turned on.
   - We are following the Schell Rule for solidification and melting.
   - We will use User Defined mixer material, alcu using .scm file. It contains properties of Al-Cu mixture material.
   - The boundary conditions for top wall are set as provided with the heat transfer coefficient – 500W/(m^2K) and side walls and bottom heat flux are taken as zero.
   - For initialization, the concentration of Cu (I am taking it as 0.03%) ; initial temperature is considered 10K above the liquidous line, which is 883K.
   - Number of time steps - 1000
   - Size of each time step - 0.05
   - Maximum number of iterations - 20.

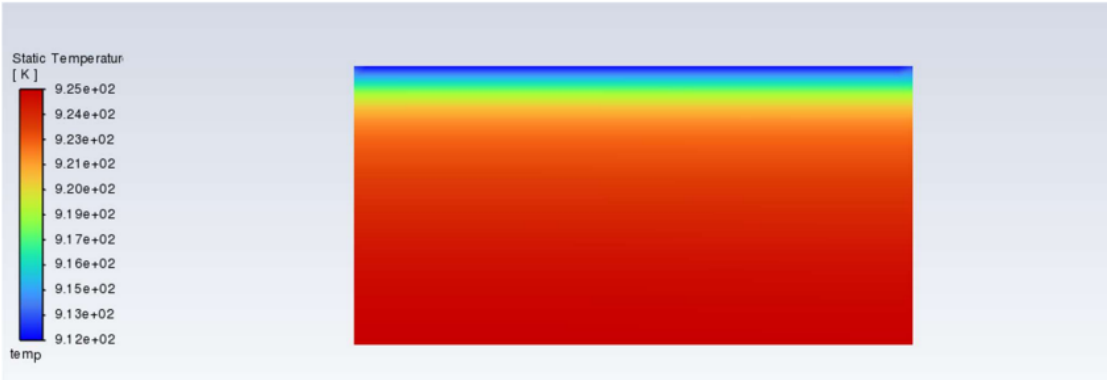
3. **Sequence of images showing the following:**

   2D Temperature profiles at approximately 20%, 40%, and 80% of the solidified area

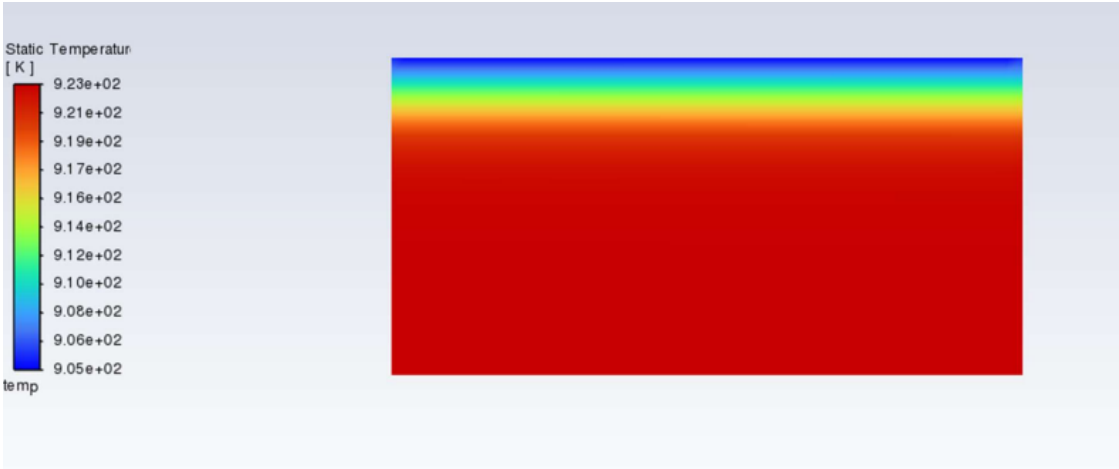
For 20 % solidified area



For 40 % solidified area

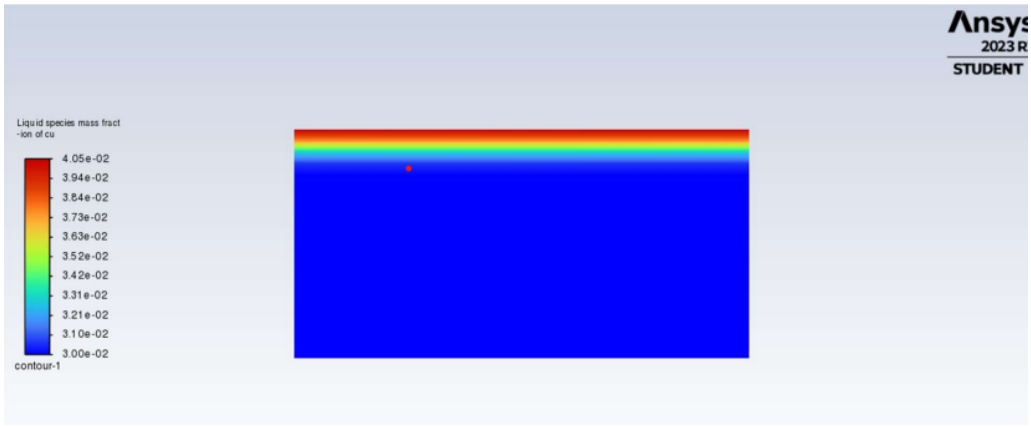


For 80 % solidified area



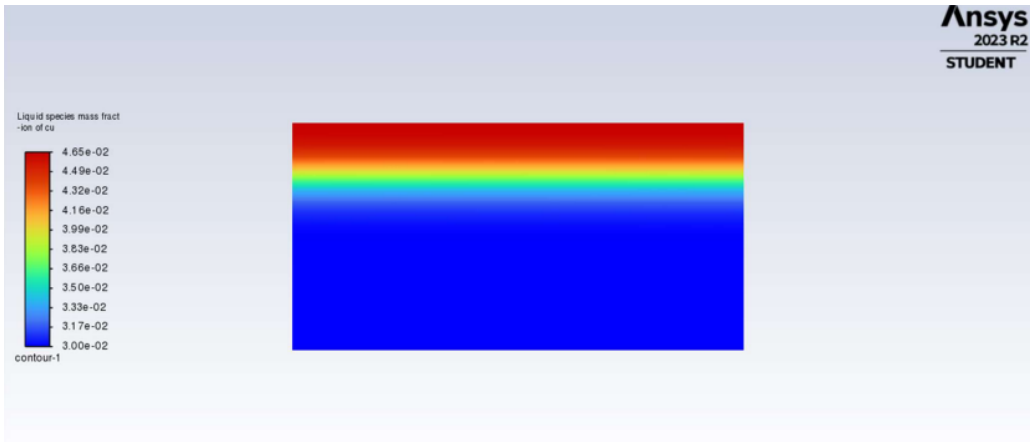
2D Liquid fraction contours

For 10 % solidified area

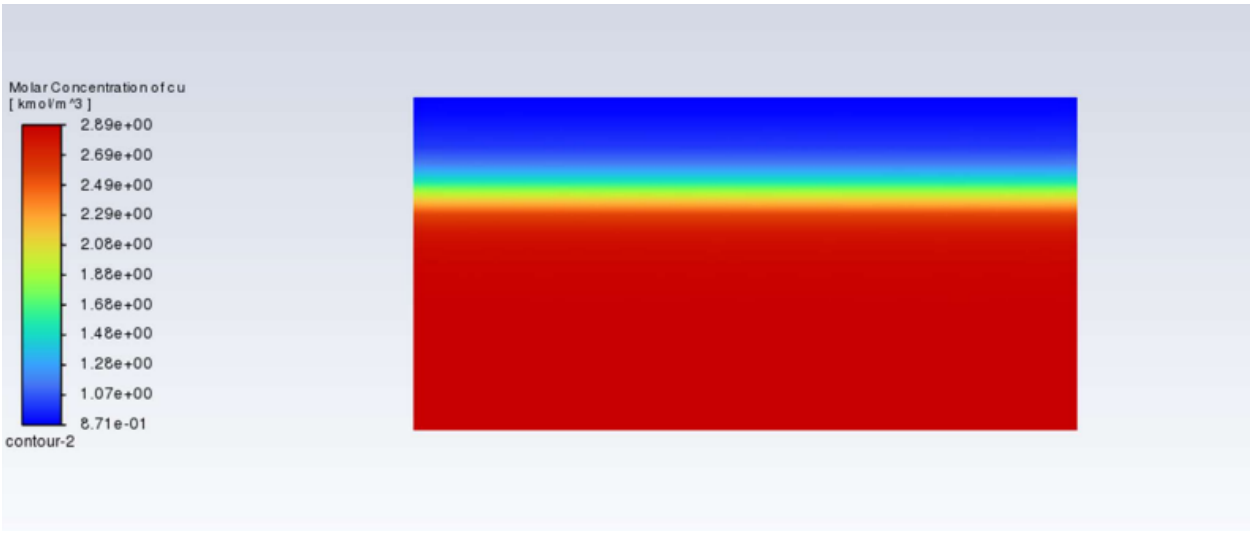


For 40 percent solidified area

For 40 percent solidified area

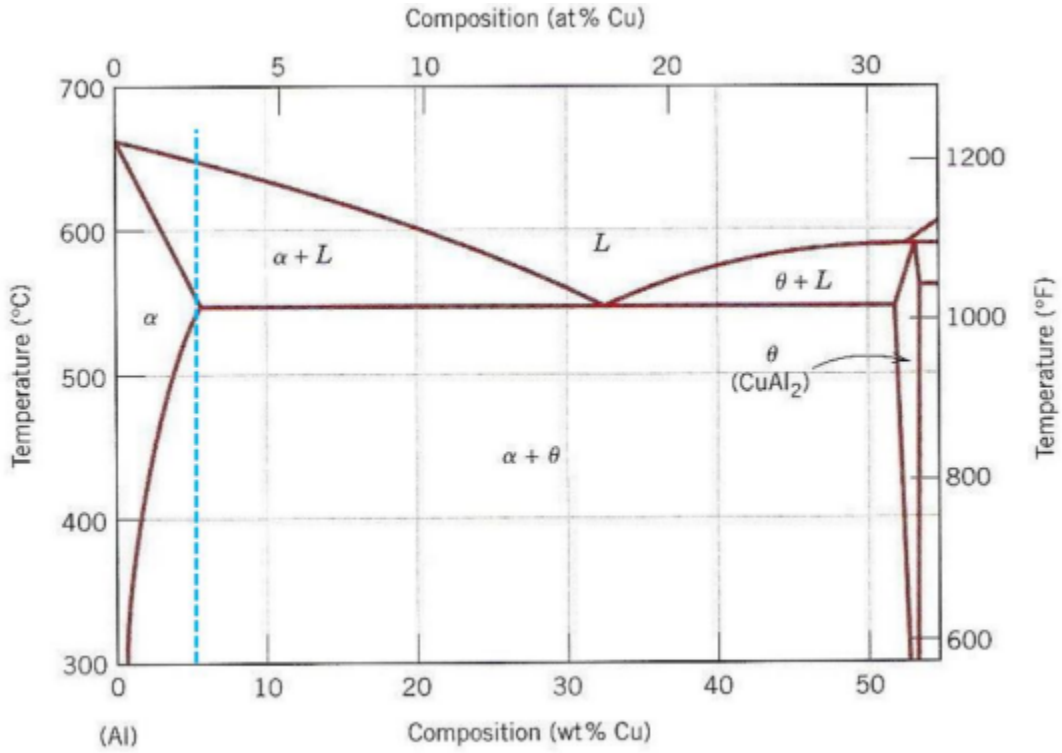


4. **No results for velocity vectors**
5. **2D Concentration field, Cu concentration at end process**



6. **Results and their explaination**

Phase diagram



We came to the following conclusions based on the phase diagram and the results: For a given weight% of Cu = 20% There are two components in this binary system: Al and Cu. The solidus and liquidus lines in the phase diagram we can see indicate the boundary above which the material is fully liquid. There is only a molten alloy mixture above the liquidus line. We are dealing with the alpha + liquid phase for the given problem. The alpha phase is a solid solution of Cu in Al. At low Cu content, it forms. We can conclude from the results and the binary phase diagram that, in general, Cu is more soluble in the Al-Cu system than it is in the solid phase of alpha-Al. The solubility of Cu in phase decreases with decreasing temperature.

7. **Summarize in your own words what you learnt from this.**

We discovered the significance of incorporating solutal buoyancy into solidification through this simulation. When we simulated Al-Cu solidification, we saw different concentrations of Cu in the liquid and solid phases because of differences in solubility. Because the mesh sizing is not very precise and because the number of steps and size of the time step taken affect the accuracy of the results, the results may not be exact. However, a noticeable trend is observed in the way things are functioning.