Project Objectives:
The objectives of this project in the second year are:

1. To develop a comprehensive EAF CFD model by enhancing the generic EAF model developed in the Year 1 to include the following:
   a. Non-uniform distribution of scrap during melting
   b. Variable heat flux rates to melting scrap based on location in furnace
   c. Transient scrap location and quantity in steel bath
   d. Model chemical reactions in steel bath
   e. Integrate transient modeling of gas flow and combustion with changing internal geometry due to scrap movement
   f. Calculate CO production from liquid steel bath
2. To conduction validation of the comprehensive model with plant data. (to be provided by SDI)

Project Tasks:
The scope of the work in year two is outlined in the flowchart below.

In Year 2, major assumptions made in Year 1 will be addressed to assist in enhancing model accuracy and complexity. The list of tasks for completion in year two are listed below:

1. Literature research, topics including but not limited to: (12 month, Jan – Dec)
   - Coherent jet interaction with solid or liquid
   - EAF slag properties and slag foaming
   - Electrodes heat transfer
   - EAF chemical reactions, including post-combustion
   - Scrap movement
   - Scrap melting
2. Develop a comprehensive model of EAF operation, including representations of electrode boring, scrap melting, liquid level, gas flow, combustion, and refining, divided into the following stages: (12 months, Jan – Dec)
o **Melting:** The melting stage covers the electrode boring into scrap, the melting of scrap above and in the bath, until all scraps have melted. The melting process will be represented by two sub models.

- **Scrap above Bath:** This portion of the model covers the melting of the scraps located above the bath and any scrap movement (slide and/or cave in). This simulation will be completed by developing a new model to represent scrap melting above the liquid bath. The intention is to simulate the scrap as a porous media, with scrap physics for sliding and/or cave-in, represented by changes in local cell porosity. (3 months, April – June)
  - The electrode heat transfer to the scrap through multi-mode heat transfer will be included.
  - Scrap size distribution will be considered to represent the industrial charging conditions.
  - Scrap movement will be investigated due to the electrodes bore in.

- **Scrap in Bath:** This section will simulate the melting of scraps located in the bath using CFD. The size and location of scrap pieces will be modeled using the PBM model. The enthalpy porosity method will still be used to track the melting of solid scrap. In order to maintain reasonable computational expenses, the simulation will model flow field inside the liquid steel bath first, then perform a transient simulation of melting utilizing that frozen flow field. (4 months, May – Aug)
  - Scrap melting will be modeled by tracking heat transfer between molten iron and solid scrap to determine the transition to liquid phase.
  - Scrap location, distribution, and quantity in the bath will be adjusted to represent industrial scenarios.
  - Heat released by chemical reactions in the bath and conducted from the electrodes will be considered.

o **Refining:** The refining stage covers the period after all scrap has melted into a liquid bath. Primary phenomena included in this stage are: Oxygen injection, chemical reactions, and fluid flow in the steel bath. The refining process will be represented by two sub models.

- **Gas above Bath:** This portion of the model captures the phenomena involved in the “freeboard” section of the EAF, above the liquid level. Gas flow, combustion, and heat transfer will be modeled to determine factors such as heat loss and energy transfer. This modeling will be completed using ANSYS Fluent, handling standard gas flow and combustion reactions of oxygen and natural gas. Temperature distribution and heat flux from electric arc energy input will also be represented. (3 months, Jan – March)
  - Gas flow from the burners and oxygen lances will be modeled using CFD to resolve an accurate flow field.
  - Electrodes heat transfer will be modeled.
  - Combustion reactions will include the reaction of natural gas and carbon monoxide with oxygen, coal combustion.
  - CO production in the liquid bath will be calculated.
  - Off gas compositions will be analyzed to validate the model.

- **Liquid Steel Bath:** This portion of the model will capture phenomena related to fluid flow below the liquid bath surface and refining efficiency. Modeling will be completed using ANSYS Fluent. The liquid, slag, and gas phases will be modeled, including chemical reactions within the liquid steel, the liquid free surface, and
flow patterns generated by the impinging supersonic oxygen jet. (3 months, Sep – Nov)

3. To conduction validation of the comprehensive model with plant data. (to be provided by SDI or from literature) (12 months, Jan - Dec)

- **Validation:** Model validation and sub-model validations will be conducted through the whole model development process.

**Deliverables:**
A comprehensive numerical model capable of predicting flow, heat transfer, and simplified melting phenomena in the EAF, as well as a baseline case of EAF operation.