Corning Future Innovator Program 2025

Corning Research Centre India

Instructions

- Form a team of **<u>two</u>** – comprising of any combination of undergraduate, graduate and PhD students. You are not eligible to enter the competition individually.
- The problem is designed to encourage interdisciplinary thinking, combining principles of engineering, material science, and sustainability. Remember, the best solutions balance technical ingenuity, practicality, and environmental responsibility.
- Follow the instructions provided for submitting your abstract.
- Teams shortlisted for the final round will be emailed by **Friday, July 11, 2025**.
- All the necessary information is provided about the problem. In case additional information is required, make suitable assumptions, and clearly state them.

Evaluation Criteria:

- **Literature Review:** How well does your submission demonstrate an understanding of existing solutions and their limitations?
- **Innovation:** How unique and creative is your approach?
- **Feasibility:** Is the solution realistic and scalable?
- **Impact:** How well does your solution address the problem? (Provide calculations/ simulation results and supporting evidence as suitable)
- **Presentation:** Thoroughness and clarity of concept explanation.

By participating, you are agreeing to following terms and conditions:

- Any information provided to Corning shall be considered non-confidential. You shall not share any information that is protected under any law, patent, confidentiality, or other contract, etc.
- Nothing provided by you shall prohibit or restrict Corning's right to develop, make, use, market, license or distribute products or services. You acknowledge that Corning may already possess or have developed products or services similar to or competitive with those provided by you.
- You shall not use any AI/chatbot generated solutions.

Problem 1: Development of Advanced Temperature Interpolation Methods

Corning manufactures world-class [ceramic substrates] and [particulate filters] that form the core of exhaust emission control systems. The manufacturing process of these cylindrical ceramic blocks is akin to brick making. Soft clay material is extruded into cylinders of the desired shape and passed through a temperature-regulated furnace. During this heating process (as shown in Figure 1), the clay undergoes multiple chemical reactions—both exothermic and endothermic—that transform it from a soft “green” part into a hard and brittle “fired” part. However, these reactions occur non-uniformly within the block, leading to differential heating and non-uniform temperature variations. Structurally, this creates space-varying temperature fields that result in thermally induced stress fields. If any region within the cylindrical block exceeds the critical stress limit, cracks may form, which is highly undesirable.

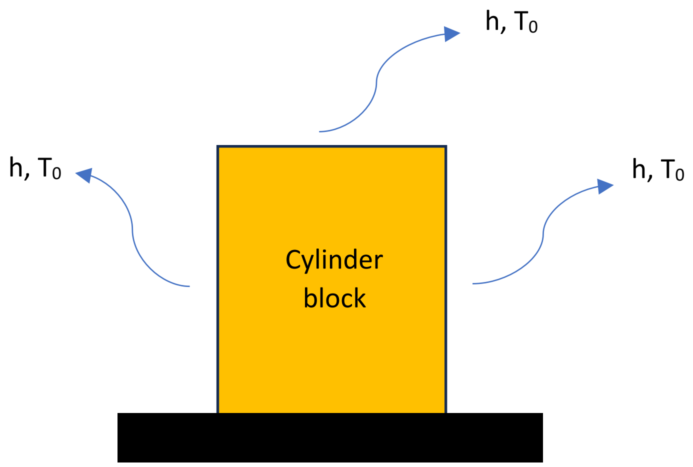

Figure 1: Cross section of Cylinder block arrangement in a furnace.

Due to the complexity of tracking or modeling internal chemical reactions, a more effective approach is to measure the temperature variation across the block and model the associated stresses to predict potential failures. However, temperature measurement presents its own challenges. First, the high-temperature environment (in the order of hundreds of degrees Celsius) requires thermocouples (TCs) capable of withstanding extreme heat, which are expensive. Second, to insert TCs in the brittle ceramic material, drilling is performed. This prevents placement of TCs very close to each other. Additionally, malfunctioning TCs may produce unreliable temperature data, requiring the model to be robust enough to handle such scenarios without discarding the entire dataset.

To simplify the problem, the axisymmetric nature of the cylinder and chemical reactions allow us to reduce the problem to a 2D analysis. Thus, instead of distributing TCs across the entire cylinder, we can limit the placement to one half of the cross-section. One sample experimental arrangement using 15 TC locations (3x5) is shown in Figure 2(a). However, stress predictions based on such sparse data collection are not very accurate. We need to improve the resolution of temperature data obtained from measurements. The interpolated 8x15 arrangement is one such arrangement of 120 data points as shown in Figure 2(b).

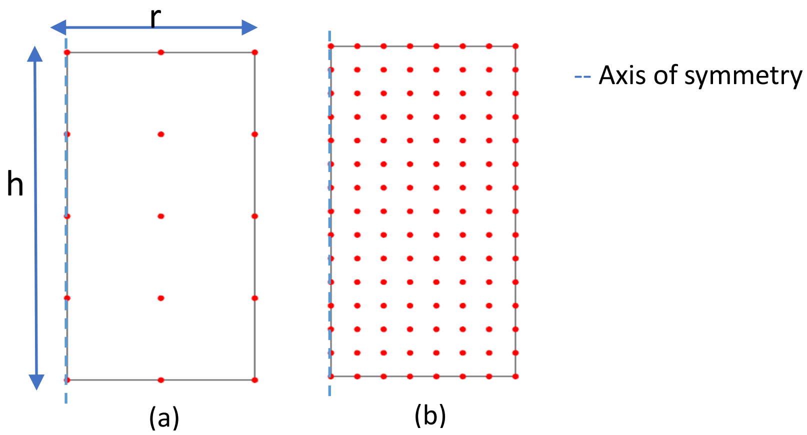

Figure 2: TC arrangement over half cylinder cross-section (a) Left – commonly available Experimental 3x5 arrangement (b) desired 8x15 arrangement for stress calculation.

One simple method for temperature interpolation is bilinear interpolation, where the temperature at an intermediate location within four points is calculated as the weighted average of the measured values from neighboring points (illustrated in Figure 3). However, this approach has limitations. It assumes linear temperature variation within the part, which is not accurate due to highly nonlinear reactions. Additionally, the malfunctioning of any TC in the neighborhood impacts the accuracy of the interpolation.

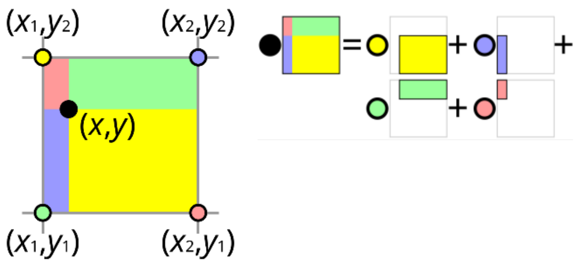

Figure 3: Illustration of Bilinear interpolation (Source Wikipedia)

Problem Statement:

Can you come up with an interpolation method to improve the temperature resolution?

Time varying temperature data for 15 measured locations (provided to you as **Data A**, with arrangement similar to Figure 2(a)) is the input for your model/method. Corresponding temperature data for 120 interpolated locations (similar to Figure 2(b)) is also provided to you. This data should be used to compare the output of your model/method. You must evaluate your model/method by calculating the error in the predicted and provided temperatures of 120 points. Once you have established your model, use it to interpolate temperatures to 120 points in arrangement for another set of 15 TCs (provided to you as **Data B**)**.**

For example, to develop methodology, a sample distribution shown in Figure 4 can be used. You can choose, say 6 (green colored dots) locations to develop the model and the rest 9 (red colored dots) to validate the model. You are free to use <u>**any other**</u> combination of locations to tune your model and reserve the rest for validation. Once you have a method established for 3x5 arrangement, extend it to 8x15 arrangement as shown in Figure 2(b).

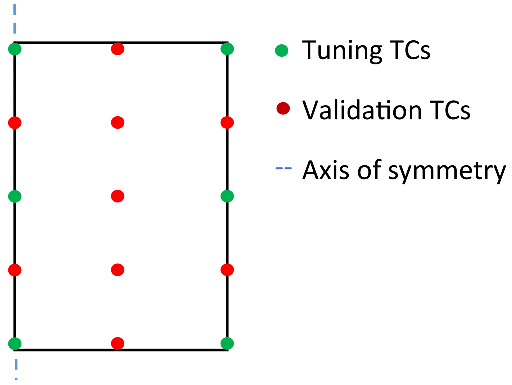

Figure 4: Suggested TC location for model development and validation

Suppose one (or a few) input TC among the given 15 TCs gives defective readings, and those values cannot be used. What modifications do you need to make in your model/approach to accommodate such a case? Demonstrate effectiveness of these modifications using an example.

Deliverables:

A) For Abstract: A 3-content slide PowerPoint presentation (in pdf format) containing:
1. Literature review
2. Novelty of your planned approach
3. Execution plan

B) For Final submission:
1. Presentation describing your methodology and demonstrating its effectiveness.
2. Maximum and minimum error obtained for temperatures provided in **Data A**
3. Temperature predictions for 120 locations using 15 location data provided in **Data B** (in csv format)

Additional points to note:

A) AI/ML based approaches are welcome; physics-based methods/approaches will carry extra weight.
B) You are free to make assumptions to simplify the problem. Though, provide the reasoning behind these assumptions.
C) You will be evaluated based on novelty in your approach to solving the problem, not solely on the error between predicted and provided temperatures. Multiple approaches will also be welcomed and encouraged.

Feel free to use whichever method you want for analysis. Hand calculations are also welcome!

Appendix

1. Reference videos:
   a. Introduction to Corning Clean Air Technologies: https://www.youtube.com/watch?v=Bigu0K3ct_Q
   b. Extrusion process: https://www.youtube.com/watch?v=Oql0eOubnmY

2. **Data A:** 15 TC data and 120 TC for model development (provided as **ps1_dataA_15TC.csv** and **ps1_dataA_120TC.csv,** respectively under **Data A** folder)
3. **Data B:** 15 TC data for model testing (provided as **ps1_dataB_15TC.csv** under **Data B** folder)
4. Material properties:
    a. Part geometry:
        i. For **Data A**: 1m diameter, 1m height
        ii. For **Data B**: 0.5 m diameter, 0.5 m height
    b. Isotropic conductivity – 1 W/m/K
    c. Density and heat capacity – 1700 kg/m^3, 1000 J/kg/K
    d. External heat transfer coefficient – 20 W/m^2/K