ASTM Industry Heat Transfer Program Discrepancies

Cameo Paper

Presented at the Brimstone Sulfur Symposium

September 12-16, 2022 at Vail, Colorado

By

Jeff Proctor, Dan Millsaps and Andy Piper
Thorpe Specialty Services Corporation (TSSC)**

** Due to significant confusion in the marketplace concerning various "Thorpe" named entities in the USA, we are clarifying that Thorpe Specialty Services Corporation (TSSC), headquartered at 3702 Mykawa Rd., Houston, Texas, 77033 is the parent holding company of J. T. Thorpe Company, Thorpe Plant Services, Inc., Thorpe International Services, Inc. and Thorpe Engineered Products Company. These entities can be accessed at www.ThorpePME.com.

ABSTRACT

Thorpe has long been involved in designing, installing, maintaining, and performing failure studies on problematic, severe service lining applications such as thermal reactors. The calculation of heat transfer thru the refractory linings is a critical design consideration for all kinds of industrial equipment for many reasons, including:

- Potential for low temperature vessel shell corrosion due to acid condensation at steel shell interface
- Potential for high temperature sulfidation corrosion
- Performance and selection of refractory materials at predicted interface temperatures
- Performance of membranes and coatings, some of which have very low allowable service temperatures
- Determination of expansion joint sizing and spacing to prevent mechanical spalling and overstressing of linings and shells
- Economic assessment of lining efficiency to minimize fuel costs

Industry personnel most often utilize refractory manufacturer's heat transfer programs or other commercially available industry programs. In performing our own investigation of commonly used programs available to refractory designers/users, we found significant differences between calculation outputs. A subsequent review of the current ASTM C680-19 specification revealed irregularities and discrepancies between equations contained in the standard versus the program source code found in the Appendix. Thorpe has brought our findings to the attention of the API SCRM (Subcommittee on Refractory Materials) along with some recommendations for a path forward. The impact of these discrepancies needs to be better understood by the Sulfur industry as it will take some time for ASTM to research and resolve the issues. This paper will highlight our general findings, illustrate why this is important to the proper design and operation of Thermal Reactors, and our recommendations

---

Thorpe is not yet prepared to share all of the details of our findings in print, but we do offer this response sent to API after our presentation to the Refractory Project Group (RPG) at the Spring 2022 Refinery Standards Meeting:

As a follow-up to the presentation, we would like to offer the following summary:

- On several occasions, inappropriate decisions have been passed down based on C680 heat transfer calculations alone, without adequate understanding of the dynamics involved. Our motivation for this study was driven by problems experienced during technical reviews of our designs by prospective purchasers.
- Our study of several sample heat transfer cases using five different industry programs illustrated an unacceptably wide range of predicted heat flux and shell temperatures.
- Product thermal conductivities ("k"values) were uniform and common among all cases, thus eliminating "k" value as a variable. Our study made no attempt to validate product K-values.
- A subsequent review of the current ASTM C680-19 specification revealed irregularities and discrepancies between the written standard and the source code found in the Appendix.
- Thorpe believes the variability of calculation results from several industry available programs is unacceptable and can result in not only design & specification errors but also an erroneous basis for fair and equal technical comparison between designs.
- Thorpe would suggest a two-step correction path forward.
    - The appropriate ASTM committee would review the C680 specification errors and omissions providing better guidance to industry programs. This would include a new Appendix with several sample lining configuration case results.
    - Upon completion of above, the industry available C680 program owners should revise their coding for compliance and check results against new C680 Appendix results for quality accuracy.
    - The above steps should result in substantially more reliable and consistent calculation results across the industry.

Thorpe continues to work with API and Industry to better understand these discrepancies and to help bring better consistency and reliability to industry heat transfer programs.