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Novel Approach to Emergency Pressure Relief Design Using Calorimetric Methods

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Technical regulations require emergency pressure relief systems in order to protect closed and heated vessels from overpressure [1]. Many chemical reactors correspond to this definition and are therefore to be equipped with a pressure relief system, consisting of a safety valve or a rupture disk followed by a piping system to a catch pot. As the pressure reaches a predefined level, called the set pressure, the safety valve or the bursting disk opens, allowing a depressurization of the vessel.

Such protection systems were traditionally designed for gas or vapor flow and non reactive vessel contents. But experience has shown that with reactive systems, two phase flow occurs, i.e. liquid is entrained with the gas or vapor. Such a flow requires larger sections for the pressure relief system. As a consequence of pressure relief, the reaction mass leaves the reactor to be transferred to a safe place, i.e. a catch pot, which retains the liquid phase and allows the vapor or gas phase to leave to a scrubber, a flare or the atmosphere. Thus the design must be performed using a specific methodology, as DIERS, which accounts for two phase flow [2, 3].

It becomes obvious that such a system cannot be used as a primary risk reducing measure. In fact according to IEC 61511 [4] it is used as an emergency measure, after all the means of safe process design, process control, safety alarms and interlock systems were used. Thus it is a last resort safety system.

Moreover its design must be performed with extreme care: oversizing may lead to higher risks since more material will leave the reactor, whereas undersizing may lead to the bursting of the vessel [5]. Therefore the data that are basis of the design must be as accurate as possible, and represent the behavior of the reacting system under deviating conditions.

Traditionally these data were obtained from adiabatic experiments. Such experiments are representative for a runaway situation, but the results must be corrected for the thermal inertia of the calorimeter, which requires the knowledge of the kinetics. Thus an iterative procedure is necessary. Instruments with a small thermal inertia are also available, but they demand a great care in order to avoid the cell bursting.

The modern tools for non isothermal kinetics [6], in combination with DSC or Calvet-Calorimetry, open a new way for solving the emergency relief system design. They deliver an information density, which is superior to adiabatic methods. This results in a greater flexibility in the choice of the relevant failure scenario and in the determination of the relief conditions. The greater accuracy of the kinetic data also leads to a greater confidence that may be given to the determination of the reaction rate at relief conditions. All these facts greatly facilitate the emergency relief design. Examples, with emphasis on the data treatment will be given.

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