Application Note

Fiber Optic Temperature Sensing of Exothermic Reactions In Packed Bed Column Reactors

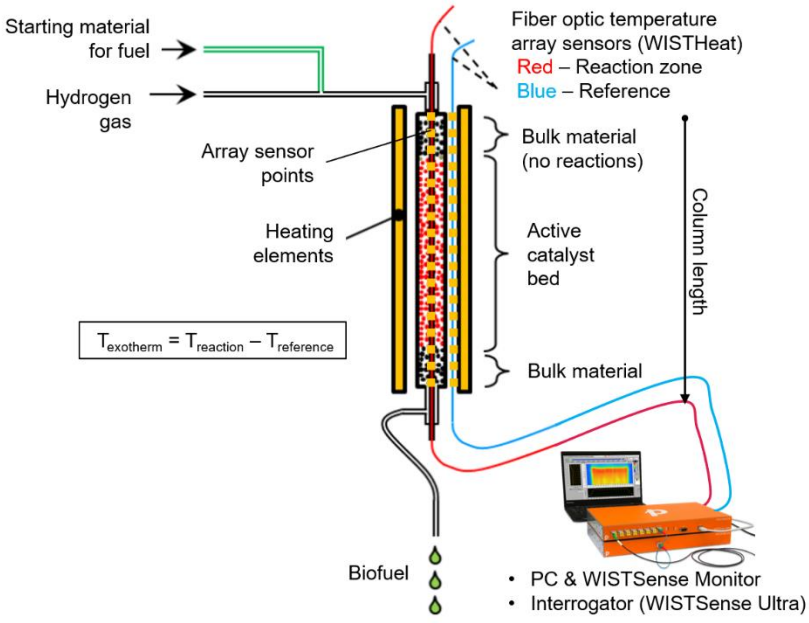
THE CHALLENGE

One of the most common chemical reactor designs, if not the most common, is the packed bed reactor. These are often of tubular vertical designs with a combination of gases and/or liquids flowing through a column, commonly from top to bottom, that are packed with ceramic pellets coated with a catalyst. The catalysts are specially designed to perform various chemical transformations such as deoxygenation, desulfurization and hydrocracking. Often, these reactions are exothermic, i.e., lead to the release of heat. The amount of generated heat depends on different key parameters that vary with, e.g., mass transfer and kinetics. However, it is very cumbersome to monitor these reactors accurately and particularly challenging to establish the amount and location of the exothermic heat being released. The long length of the reactors and the unintentionally wear of the catalyst that may move the reaction zone increase the measurement difficulties.

THE SOLUTION

Optical Fiber Bragg grating (FBG) sensors, in which measurements are made inside miniature (<=250µm) glass fibers, have a very small form-factor, support a large number of measurement points with a single sensing cable, are zero power so intrinsically safe, and provide very high resolution measurements over an extraordinarily large temperature range. So, they are ideally suited to meet this measurement challenge.

The chemical process laboratory in Södertälje of the Research Institute of Sweden (RISE) has therefore built an experimental packed bed reactor, as shown in the figure to the right, with fiber optic temperature array sensors to overcome these limitations. The design incorporates sensors that have been developed and delivered by Proximion. The sensing system has the capability to measure relatively minor exothermic reactions that occur along the complete length of the column.



The experimental packed bed reactor for conversion of forest product to biofuels (the Research Institutes of Sweden, Södertälje).

Proximion AB
Skalholtsgatan 10
SE-164 40 Kista, Sweden

phone: +46 8 750 48 88
info@proximion.com
www.proximion.com

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Instrumenting the experimental reactor with this significantly improved exothermic temperature sensing offers the following potential benefits:

Increased conversion rate, capacity and product quality
via better temperature measurements

Improved control algorithms and reaction models
via modelling from high quality kinetic data

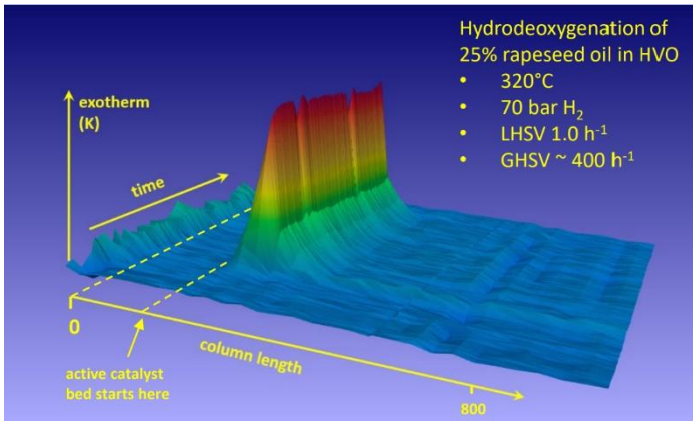
Optimized process control (e.g. maintaining steady state)
via real time data along the complete column

Knowledge of the actual location of the reaction in the column
via real time data

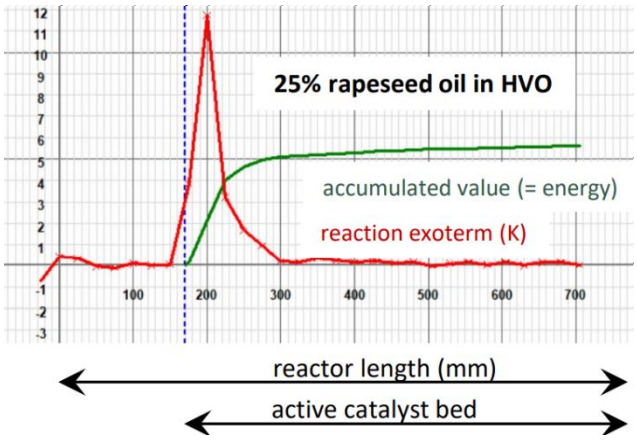
Monitoring of the bed *(packing)* and catalyst *(activity, poisoning and coking)* over time and location

Safe *(no electrical power)* and low influence *(small thermal mass)* measurements in ATEX and high EMI environments

The RISE experimental reactor is used in research about the production of biofuels from forest products. The model system selected for the evaluation of the measurements technology was hydrodeoxygenation of rapeseed oil with the exothermic measurement over time vs. column length as shown in the below figure. The high capability of the fiber optic sensing was demonstrated in this way.



Measurement of exothermic release in a packed bed column reactor using two Proximion array sensing probes, one within the reaction zone and one as reference outside the reaction zone (analysis by the Research Institute of Sweden, Södertälje).



The extracted exothermic temperature heat measurement (red line) and the integrated temperature curve / accumulated energy (green line) (analysis by the Research Institute of Sweden, Södertälje).

See a video summary of the results at www.proximion.com/media

THE COMPANY

Part of the huge Hexatronic Group, Proximion AB designs and manufactures customized, high performance fiber optic sensor systems for use in numerous harsh environment applications. Proximion technical experts have experience applying the unique advantages of FBG technology to a wide range of industrial assets, including electric motors, generators, steel foundries, chemical reactors and aircraft. proximion.com

Proximion AB
Skalholtsgatan 10
SE-164 40 Kista, Sweden

phone: +46 8 750 48 88
info@proximion.com
www.proximion.com