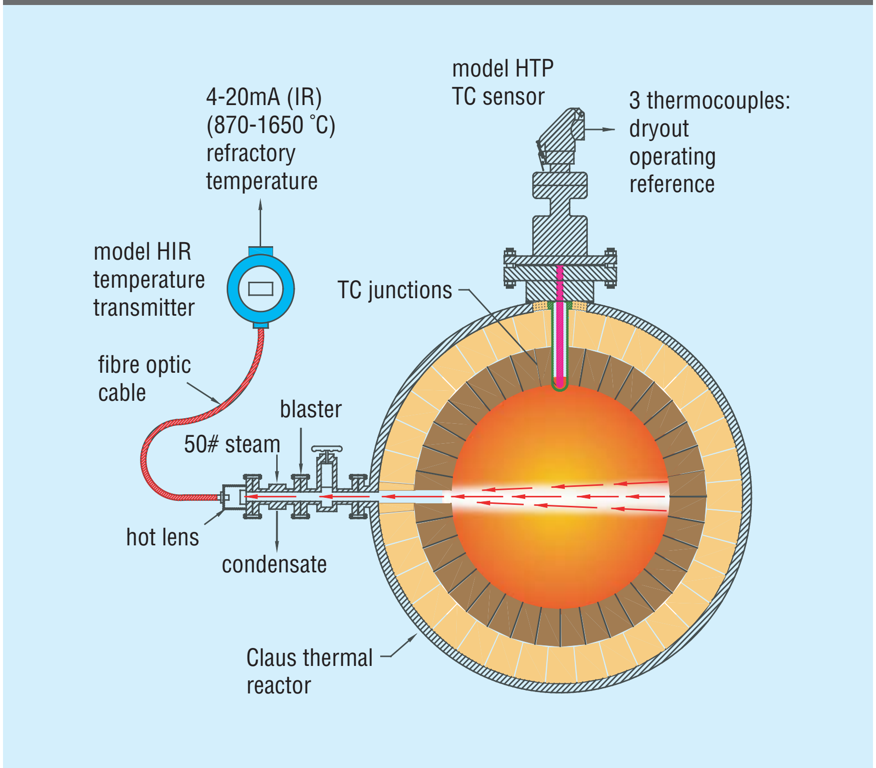
Improved temperature measurement

At *Sulphur 2004*, **Steve Croom** of Delta Controls discussed new technology for reliable, long term Claus furnace temperature measurement in the range 1650 °C to 1925 °C. Measurement of these very high temperatures can now be achieved with a combination of a well-proven, specialised, purged thermocouple assembly and a new infrared system.

A specialised thermocouple assembly known as the HTP Claus reaction furnace thermocouple, introduced over 35 years ago, has evolved into a very successful self diagnostic unit, installed in Claus furnaces throughout the world. To meet the demands of oxygen enrichment, it now offers the capability to measure temperatures up to 1925 °C.

In recent years, a new infrared transmitter has been developed to supplement the HTP thermocouple device. For oxygen enrichment operations, the combined system (thermocouple and infrared) is claimed to provide the best available temperature measurement technique available for Claus service (*Fig. 1*).

Fig. 1: **Claus reaction furnace with HIR infrared & HTP thermocouple**



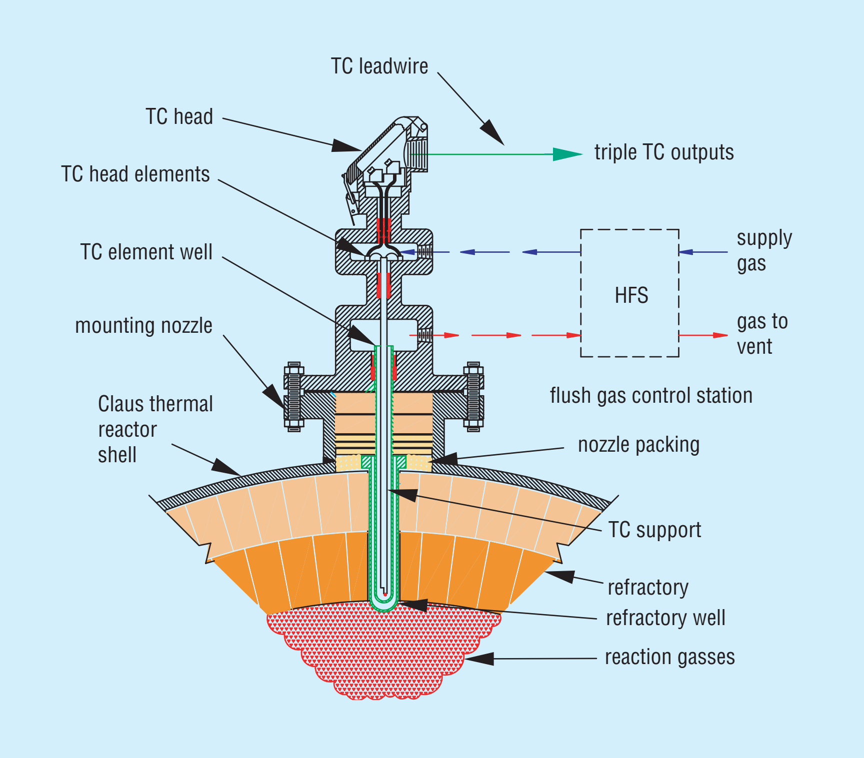
The Delta HTP Claus reaction furnace thermocouple

Designed specifically for the Claus reaction furnace, the HTP is a highly reliable and accurate temperature measurement device. It provides three separate output signals, two to measure the refractory hot face temperature and another to measure the low temperature refractory dry-out and curing cycle.

The two separate thermocouple elements measuring the hot face temperature provide a self-diagnostic function that warns the operator of any failure or inaccuracies of the thermocouple. This is accomplished by encasing one of the elements in solid ceramic; the other is installed in a conventional manner with the junction protruding into the thermowell. In the unlikely event of a failure of the purged thermowell, the corrosive gases would attack the protruding element, whereas the encased one would be protected for an extended period of time. The corrosion would cause the signal to begin to drop relative to the actual temperature. The encased element would continue to provide an accurate signal. The disparity between the two output signals would provide a positive indication of a malfunction. In this manner, the operator will never be misled by a declining signal. (All temperature measurement devices usually initially exhibit a false low reading prior to failure).

A flush gas purge (N_2 or clean, dry air) is essential to proper operation and longevity of the thermocouple system. This purge, which does not enter the furnace, is maintained at a constant low flow through the

Fig. 2: **The HTP assembly**



internal passages of the thermocouple. A slight elevated backpressure of the flush gas is maintained by the use of a flow meter equipped with a flow control valve located at the purge outlet. The purge function is most easily accomplished with the use of a convenient "flush gas" control station equipped with the pressure regulator, filter, drip well, flow meter and valve.

The HTP assembly (*Fig. 2*) uses a unique large protective ceramic refractory well to shield the inner ceramic thermowell and protect it from physical harm such as movement of refractory, quenching and severe thermal shock conditions.

The installation of the HTP assembly is simple and straightforward; all of the essential tools/fixtures for proper installation may be supplied with each HTP thermocouple.

With today's higher operating temperatures, high accuracy as well as high temperature capability is required. The HTP thermocouple reads temperature directly, provides typical accuracy of ±0.5% and never requires calibration. The high-temperature range (1925 °C) is recommended for high oxygen enrichment.

Until recently, most temperature instruments have had limited capability or have been set up to read a maximum of 1650 °C. However, in oxygen enrichment units, an upset incident can easily cause the temperature to rise above 1650 °C and there is no indication of what the actual temperatures were or for how long. Panel board instruments simply indicate a flat line at 1650 °C.

Knowledge of the actual temperatures encountered helps to assess any possible damage that may have occurred. Therefore, it is recommended that temperature instruments with the capability to read at least 1925°C be utilised.

The HTP thermocouple assembly is relatively inexpensive; budgetary cost for the complete HTP assembly is about €4,500, and the installation cost is usually less than €2,500.

The Delta HIR infrared temperature transmitter

Infrared temperature transmitters have been used in this service for decades with success. This technology measures infrared energy and from this measurement, it provides an inferential temperature measurement. However, these infrared units have typically required considerable routine maintenance such as cleaning the IR view port, removing built-up debris from the refractory bore and periodic calibration verification. Also, it has been normal to recommend that IR units be annually returned to the manufacturer for complete calibration and adjustment.

A relatively new type of infrared temperature transmitter, designed and built specifically for Claus reaction furnace service, has been introduced over the past few years. This unit, the Model HIR as shown in *Fig. 3*, significantly lowers the cost of ownership by eliminating the need for maintenance and providing improved reliability.

This new unit uses a "hot nozzle" lens assembly, which keeps the sight port glass lens at about 150 °C, well above the solidification point of sulphur of 119 °C. A 3.5 barg steam-jacketed lens housing prevents the deposition of sulphur on the glass or in the nozzle.

A small N_2 or air purge (approximately 20 lpm) in the view port keeps particulate and dust from collecting on the glass. This combination of heat and low flow purge gas essentially eliminates the need to periodically rod-out or clean the viewing window. However, this "hot-nozzle" design, due to its high temperature, cannot offer a sight port.

In many installations, the bore through the refractory becomes obscured with the build-up of sulphur, refractory cement and other debris, which blocks the infrared path to the lens. The Model HIR incorporates a "Bore-Blaster" feature, which is a unique large annular steam port located in the mounting flange. In the event of a blockage, steam is introduced through this large port, removing the blockage.

To eliminate the need to recalibrate the sensor and electronics, the HIR uses proven semiconductor type technology, which compared with the sensors previously used, does not exhibit the tendency to lose accuracy over time. This eliminates the requirement to periodically perform expensive recalibrations.

With the "HTP" thermocouple also installed in the reaction furnace, there is no need to verify the HIR device accuracy using a sacrificial "insertion type" thermocouple.

The electronics and sensor unit is mounted remotely from the reaction furnace nozzle and uses a high-temperature, armoured fibre-optic cable to connect it to the lens assembly, which is mounted to a block valve on the nozzle. In this manner, the electronic components are located away from the heat and vibration of the furnace, providing high reliability.

The HIR transmitter is relatively inexpensive to purchase and install. The budgetary cost is approximately €6700; installation is typically €3000. There is no expected maintenance cost thereafter.

The HIR transmitter uses two-wire 24 VDC loop power and provides a 4-20 mADC output signal. No external source of 110 or 220 VAC power is required.

The HIR transmitter uses notch optical filters to minimise absorption errors in viewing through hot process gases to "see" the hot refractory face. Two ranges are available, 870-1650 °C or 870-1925 °C, recommended for high O_2-enrichment service. S

Fig. 7: **HIR infrared temperature transmitter with hot-lens & bore blaster**