# Innovative temperature control for heat treatment of recyclable materials in rotary kilns

**by Albert Book**

The increasing demand for raw materials requires improved processes to recover the highest possible proportion of recyclable materials in the treatment of waste. In addition to classical waste incineration, new plant concepts serve for energy generation and pyrolysis, i.e. the thermal decomposition and elimination of waste in particular, and for the recovery of valuable raw materials. For the heat treatment of bulk material processes, indirectly heated rotary kilns are used for this purpose. A high throughput can be achieved with a controlled temperature profile. The optical temperature measuring method is used to measure the temperature. Pyrometers ensure the fast and wear-free measurement from a safe distance. The following article describes the correct selection and use of pyrometers for measuring the surface temperature of encapsulated rotary kilns.

## Thermal recycling processes

The demand for raw materials is continuously growing due to the worldwide demographic development. For reasons of sustainability it is therefore important not simply to destroy the valuable raw materials in incineration plants, but to recover them in appropriate recycling processes. Thermal heat treatment is a process for the recycling of plastic waste, used tyres, sewage sludge or electrical scrap. For energetic reasons, rotary kilns are preferably used instead of classical waste incineration plants. The aim is to recover a high proportion of recyclable materials.

Rotary kilns are frequently used nowadays for the thermal treatment of bulk materials or for the calcining of raw materials, building materials, ceramic products or pharmaceutical products.

The bulk material is constantly moved through the kiln during the heat treatment by the rotation of the slightly inclined tube. In addition to the mechanical influence, the treatment process is characterized by the rotational speed, the flow behaviour, the density of the material and, in particular, the temperature profile along the rotary tube. Temperature distribution therefore plays a decisive role in the process design of the heat treatment plant.

Depending on the type of heating, a distinction is made between directly and indirectly heated rotary kilns. Indirectly heated kilns are used when the bulk material to be treated has to pass through a defined temperature profile, the material tends to strong development of dust or when it is to be treated in a special protective atmosphere. The rotary tube is installed in an encapsulated housing. Heating is achieved by gas burners, which are divided into several control zones along the tube according to the required temperature profile and flush the rotary tube with their flue gases.

## Infrared temperature measurement

Optical temperature measurement using a pyrometer is ideal for recording the temperature profile of the rotating rotary tube. They measure the infrared radiation of the shell and calculate the surface temperature on the basis of Planck's radiation law. The measurement is contactless from a safe distance and therefore wear-free. The temperature is determined within a few seconds and is available as controlled variable for the burner control unit.

When selecting the devices, you can choose between two measuring methods. Spectral pyrometers measure the infrared radiation at one wavelength. Two-colour pyrometers measure the radiation at two wavelengths. The quotient of the two radiation intensities is proportional to the object temperature (**Fig. 1**). Both measuring methods are used depending on the shell temperature, the measuring conditions and the required measuring accuracy.

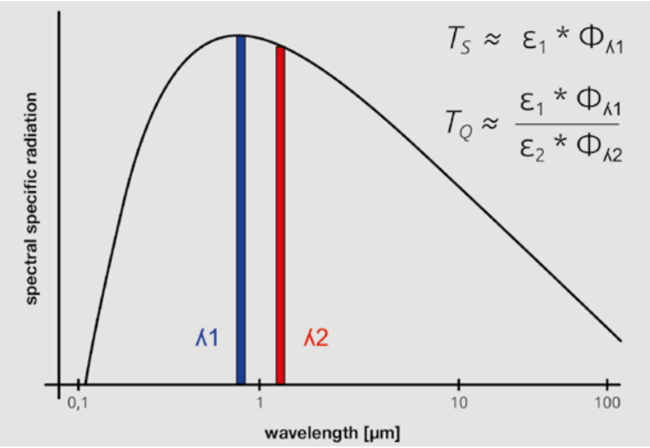


**Fig. 1** *Spectral pyrometers measure the radiation ($T_S$) at one wavelength, whereas two-colour pyrometers determine the temperature from the ratio of the radiance of two wavelength ranges ($T_Q$)*

Since infrared temperature measurement is an optical measurement method, both the surface of the shell and contamination in the view field of the pyrometer can influence the accuracy and reliability of the measurement. If the radiation property of the shell surface of the rotating tube, i.e. the emissivity, changes due to dirt or ageing, this has a direct effect on the measured value with spectral pyrometers. The two-colour measuring method is nearly insensitive to such interferences. A contamination of the pyrometer lens or of the sight glass as well as a decrease of infrared radiation by dust, vapour and smoke in the view field leads to a decrease in temperature in spectral pyrometers. Two-colour pyrometers still deliver safe measured values even with a degree of decrease of infrared radiation of 90 %. The only limitation of the quotient measurement is, for energetic reasons, the higher start of the measuring range from approx. 650 °C.

## Measuring points and installation of pyrometers

One pyrometer per burner zone is mounted along the axis of the kiln to record the temperature profile crosswise and lengthwise of the rotary tube and to control the separate burners individually (**Fig. 2**).

Due to the rough measuring conditions within the encapsulation of the rotary kiln and the different shell surface, two-colour pyrometers are used for metrological and safety-related aspects if the shell temperature is sufficient. At measuring points where the shell temperature can drop below 650 °C, only spectral pyrometers can be used. In order to keep the opening of the kiln as small as possible or to be able to use existing openings of thermocouples, a high-quality and parallax-free lens with a narrow and, if possible, parallel viewing cone should be used. If the geometrical and optical axes of the instrument are not identical, i.e. the instrument squints, this can lead to a constriction of the measuring field of the pyrometer by the mounting fitting and opening of the kiln. Spectral pyrometers react directly with a lower indication. Two-colour pyrometers can even compensate such homogeneous signal weakening up to a certain extent. They are therefore less sensitive to alignment accuracy.

Flames can interfere with the optical temperature measurement. Therefore, when determining the mounting locations of the measuring device, it is important to ensure that the distance between the flame and the view field of the pyrometer is sufficient.

For mechanical and thermal protection of the pyrometer lens, a quartz glass is usually inserted into the mounting. Thanks to the bayonet locking, disassembly and assembly for inspection and cleaning of the protective glass or viewing opening is easily and quickly possible, even without tools, during operation (**Fig. 3**). A purging air nozzle with circulating air guidance provides optimum protection against contamination with minimum air consumption.

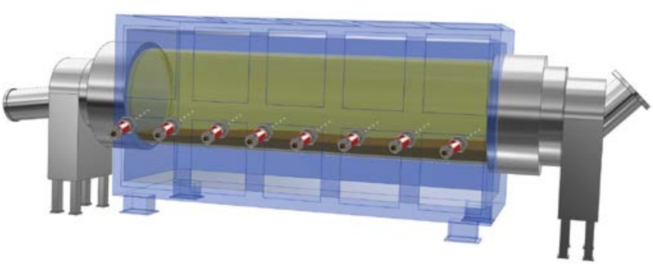

**Fig. 2** *Indirectly heated rotary kiln with one measuring system per burner zone*

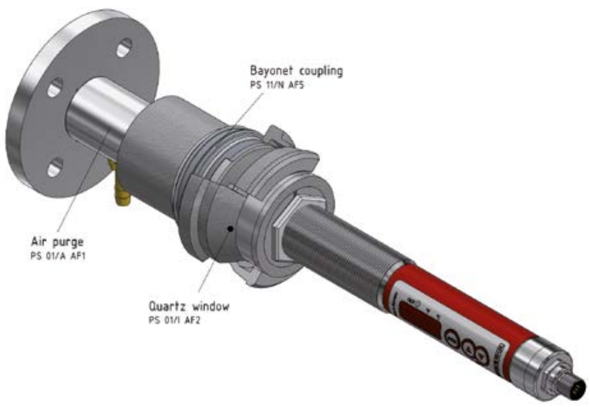


**Fig. 3** *Measuring system consisting of pyrometer and mounting with bayonet locking, quartz glass and purging air nozzle*


**Fig. 4** *Modern pyrometers with IO-Link interface*

To further increase the safety and reliability of the measurement, modern two-colour pyrometers have a SCM function (Smart Contamination Monitoring). The device permanently monitors the contamination of the protective window or the constriction of the kiln opening. A warning message is generated in the event of an upcoming critical condition. The sensitivity of the warning threshold can be adjusted.

## Digitization of production process

The analogue current output is still frequently used for the connection to the system control. With the implementation of Industry 4.0 and the networking of machines and plants and the digitization of production and service processes, interference-free digital interfaces are increasingly being used.

With the introduction of the new IO-Link interface technology, a generational change takes place in the field of digital communication. With IO-Link a standardized, manufacturer-independent and fieldbus-independent communication concept was developed in accordance with IEC 61131-9. Devices with IO-Link interface can be integrated into all common fieldbus control systems such as Profibus, Profinet, Ethernet, Modbus, EtherCAT or CAN-Bus for process automation using standardized IODD drives (**Fig. 4**). In addition to various measured values, diagnostic data can be evaluated and fault messages such as a warning in case of a dirty lens can be transmitted to the control system. This is the basis for modern service management with demand-oriented maintenance in the event of a malfunction.

IO-Link devices can be centrally parameterized from the top level of the process control even dynamically during operation. After a sensor has been replaced, the identification is automatically checked and the configuration parameters stored in the IO-Link master are transferred to the sensor. The installation of an incorrect device version and incorrect operation can therefore be excluded.

Another significant advantage of IO-Link is the very simple, fast, reliable and cost-effective wiring via standardized cabling and screw connections.

## Conclusion

In order to achieve a high degree of raw material recovery in heat treatment processes, innovative measuring devices are necessary to meet the requirements for precise and reliable temperature measurement.

Modern two-colour pyrometers for optical temperature measurement are nowadays able to meet the requirements for a permanent and reliable measurement even under rough production conditions without wear and maintenance.

With the implementation of Industry 4.0, the use of the digital interface is absolutely necessary to be able to evaluate further measurement data, diagnostic information or fault messages.

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