Innovative 'thru-process' temperature profiling technology to meet the challenges of monitoring modern robot loaded T6 rotary hearth furnaces

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In the automotive industry, the trend towards lightweight construction continues and, with the increasing development of high-strength aluminium alloys, it is constantly finding new application areas. In engine technology, these materials have replaced steel in many places. The heat treatment equipment required for this purpose must meet the high standards of automotive production. Not only does low cycle times and high process reliability play a role here, but also, the ever-increasing demands for quality assurance and seamless traceability must be integrated into ongoing processes.

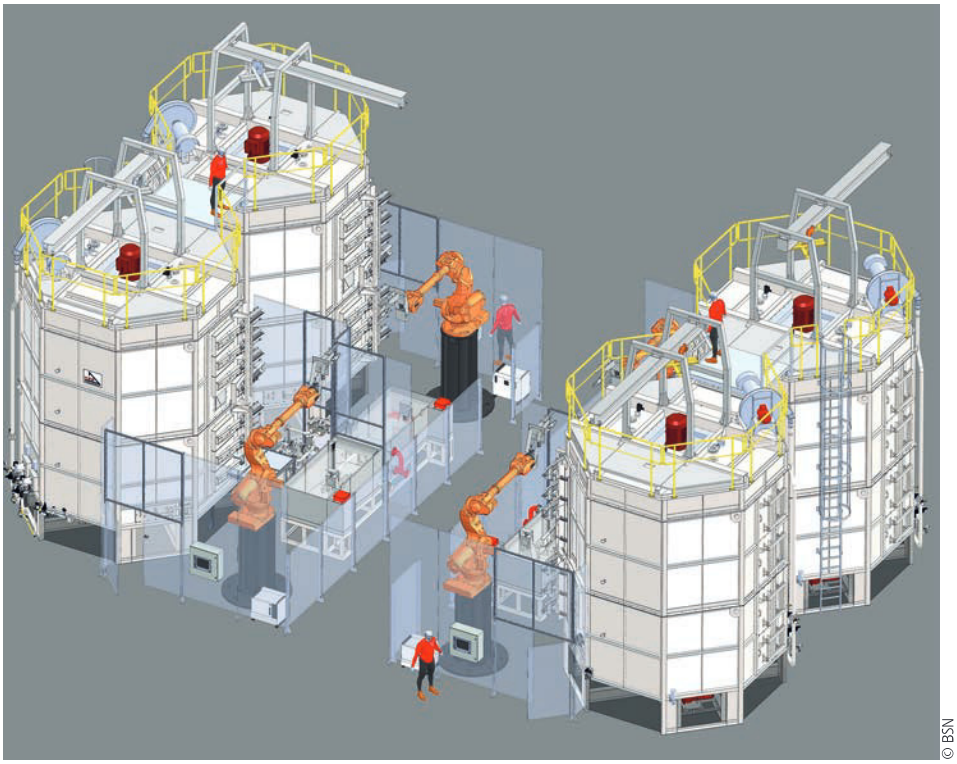

Fig. 1: Sketch of a rotary furnace plant with quench bath

BSN Thermprozesstechnik GmbH based in Simmerath, Germany, has broken new ground in the heat treatment of engine blocks, cylinder heads and similar components made of aluminium with the innovative concept of multi-level rotary hearth furnaces for solution annealing, quenching and subsequent artificial aging.

These rotary hearth furnaces (Fig. 1) allow, in contrast to other furnace concepts, the required reproducible individual treatment of the components. Due to the central robot loading and unloading and the associated elimination of charging racks, (the grippers place the component directly on the respective receiving places in the oven), the costly return transport of these transport aids is eliminated and efficiency increases. Due to the special air flow a uniform and fast heating of all parts is provided. This means that all components can be heated with exactly the same parameters without mutual interference.

Despite the success of the furnace technology, a problem arises. How can you measure the product temperature in such a rotary furnace in a meaningful way and comply with process standards? The furnace itself, like all industrial furnaces, is equipped with temperature sensors for environmental monitoring and regulation. But these sensors do not give any indication of what really happens to the product temperature within the furnace. Previously, the actual product temperatures were measured using trailing thermocouples that had to be routed through the furnace. Naturally, this is not possible with this special oven design because the thermocouples

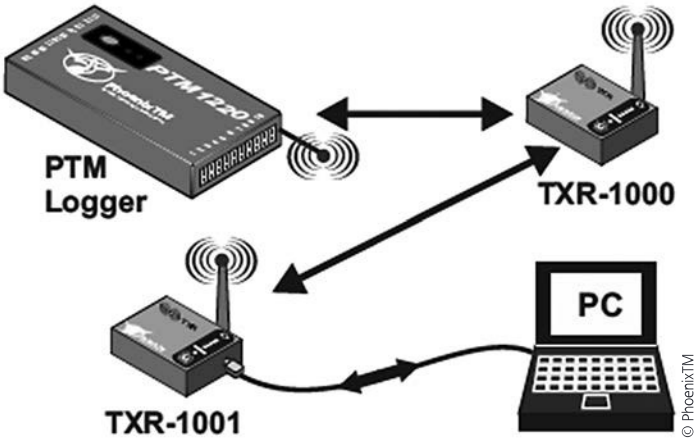

Fig. 2: PhoenixTM 20 channel data logger and schematic of how the RF telemetry system operates providing live process monitoring direct from the furnace

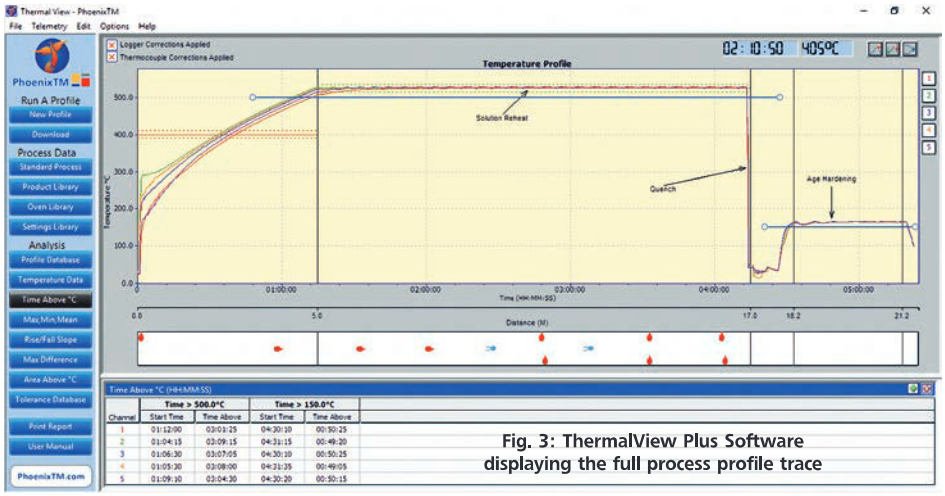

Fig. 3: ThermalView Plus Software displaying the full process profile trace

would wind up. Conventional measuring systems require too much space to provide the required thermal performance.

PhoenixTM, manufacturer of temperature profiling systems, has tackled this particular problem. In close cooperation with BSN, systems have been developed that can be integrated into the process without any loss of time. The PhoenixTM systems work according to the 'thru-process' temperature profiling principle. A data logger, protected by a thermal barrier, is transferred through the furnace with the product and collects data at up to 20 measuring points. Thermocouples, which are attached to or inserted into the product, record the actual product temperatures and store them in the data logger. The data logger can be supplied with a two-way RF Telemetry option, in which case, the recorded temperature readings can be transmitted directly from the furnace live to the monitoring PC (Fig. 2). The evaluation software ThermalView Survey or Plus generates a complete report and gives you an idea of the respective temperatures at a glance (Fig. 3).

The difficulty arises in the monitoring system design from the conflict between limited space and demanding heat protection performance. It must also be ensured that the thermal barrier is adapted to the component in such a way that the robot can still grasp it automatically.

The PhoenixTM thermal barriers work using one of two principles:

1. *Water-cooled thermal barrier.* In these barriers the data logger is protected in a waterproof housing. The heat protection performance is achieved by evaporating water. The size of the tank must be adapted to the respective process duration.

2. *Heatsink Technology.* Here the heat protection is provided by microporous insulation material and a heat sink surrounding the data logger. The heat sink is filled with a special salt that absorbs the heat and liquefies at temperatures of 58 °C / 136 °F.

The water-cooled barrier design is chosen specifically for monitoring the rotary hearth furnace as it suits these applications due to its more compact design.

In several cases, rotary hearth furnaces were implemented for solution annealing, water quenching or air quenching and subsequent artificial aging. Engine blocks were milled out so that the thermal barrier fitted inside and also the thermal load capacity for the relatively long process was not exceeded (Fig. 4). The system with the data logger in the barrier does not protrude beyond the external dimensions of the component. The gripper takes the prepared block (the thermocouples were placed in advance in the relevant places) and puts it, without interrupting production in the furnace chamber (Fig. 5). The furnace profile runs with temperatures around 550 °C / 1022 °F and a process time of several hours. The PhoenixTM system is then removed by robot, after the furnace, and placed in the quench bath. In the water, the barrier water tank fills up again preparing it for the next hot aging furnace. Thus, longer process times are no problem and the automatic assembly makes it very easy for the user to measure regularly and reproducibly according to quality specifications and standards.

By implementing the PhoenixTM system the customer can understand, control, improve and validate his T6 rotary furnace process with ease and efficiency and ensure that the heat-treated product meets the highest of automotive quality standards.

PhoenixTM will be exhibiting at Aluminium USA 2019 in Nashville from 12-13 September, Booth 628; www.phoenixtm.com

Fig. 4: Prepared aluminium part fitted with the PhoenixTM profile system

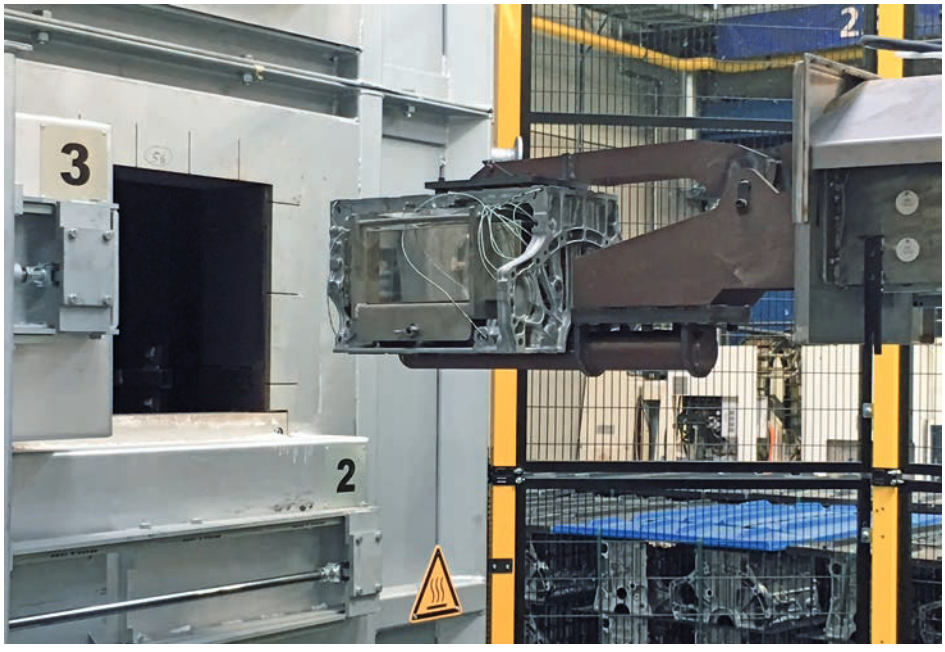

Fig. 5: Component and PhoenixTM system being loaded into furnace by gripper