A remote engineering solution for automating a roller hearth kiln

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Extended Abstract

Two kiln types are used for firing materials in the ceramics industry: the tunnel kiln and the roller hearth kiln. A major difference between these two kiln types is that the former allows a faster firing cycle with considerable productivity gains and energy savings [1], [2]. The use of roller hearth kilns was initially confined to floor and wall tiles, but since some years ago it has been extended to all types of table ware (decoration, biscuit firing, gloss firing, in-glaze), sanitary ware, and even clay materials for civil construction. This type of kilns usually works 24 over 24 hours, while also supporting break periods on the weekends (or longer periods), with quick setup times, which presents and additional vantage over tunnel kilns. Depending on the type of insulation and conveyor rollers used, it accepts temperatures of up to 1250 ºC, for pottery firing, or up to 1400 ºC, for porcelain firing. The roller hearth kiln to be automated, in particular, measures 145 metres long by 2.4 metres width, and uses natural gas, which has an higher calorific power than other fuel types and therefore allows a more uniform firing and hence an higher productivity. The target kiln contains 35 ramps, where 32 are for firing and 3 for cooling. Each stage is 4 metres long and contains two thermocouples and two valves or servo motors.

Figure 1 presents a simplified view of the roller hearth kiln operation. A new row of tiles enters the conveyor stage through the left side and, if there is a blank space available for firing, it enters inside the firing chamber. If there is no space then it goes into a waiting stage until there is one. The materials move inside the chamber by means of a conveyor belt that rolls by the action of special ceramic rollers, adapted to work inside the firing chamber. The hydraulic press that eliminates any empty spaces within one row of tiles (X-axis) is represented in blue colour while two sensors (bottom of figure 1) detect any spaces between two adjacent rows (that move along the X-axis). The bottom part of figure 1 illustrates the output of the roller hearth kiln where the finished up products are taken from.

There are two critical problems associated with the roller hearth kiln that are specifically dealt within our work: 1) currently the temperature monitoring process, done by thermocouples, and the control of the valves imply a human operator – this fact is a first indicator of a possible automation solution; and 2) sometimes the conveyor rollers are damaged, which causes some tile rows to fall to the kiln interior floor. Most of the times these tiles break when they hit the floor and hence productivity falls down. As the interior part of the roller hearth kiln is not monitored in real time, in an automated way, the human administrator usually takes some minutes to detect the problem and to stop the process. Once the conveyor belt is stopped, the damaged conveyor rollers have to be replaced, the broken tiles (i.e. the wasted materials) have to be removed from the the inside part of the kiln, and the all process may start again. The considerable losses in terms of production time and wasted materials are two strong arguments in favour of implementing an automation solution. In the envisaged solution, once a problem is detected by specific sensors, an automatic process is started to help overcome any potential damages. Even if some parts of this process imply a human intervention (e.g. replacing the damaged conveyor rollers) a prompt reaction will clearly improve the process productivity.

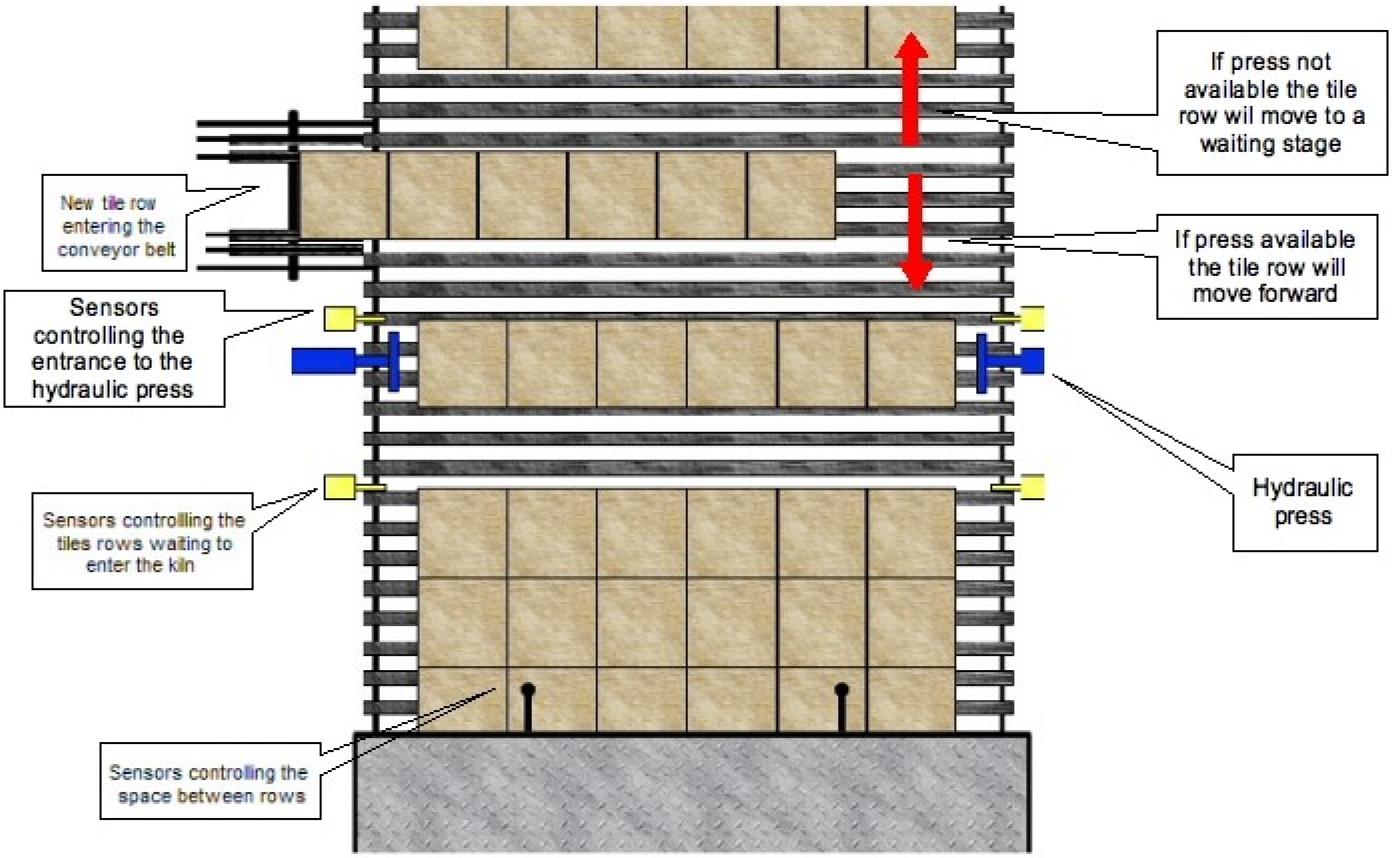

Figure 1: A simplified schematic diagram of the roller hearth kiln operation.

The goal of the present work is to develop a remote engineering solution for automating the roller hearth kiln. The solution must be a low-cost and flexible one based on an Ethernet network. The control / monitor process should have an interface accessible through an Intranet, preferably using a simple web browser. The solution under consideration is supported by a new prototype of a Micro Web Server (MWS), developed at RexLab, where the temperature sensors will connect to via an A/D converter with 32 input channels. The set point of each temperature sensor (i.e. the thermocouple) is to be done through the web page hosted by the MWS (configured with a fixed IP). This page will also display the temperature read by each sensor, updated every x seconds. The person in charge of the production process will have administration privileges when accessing this page, which will allow him to modify parameters, stop and start the roller hearth kiln, among other requirements.

[1] Handy Manual, “Ceramics Industry”, output of a Serminar on Energy Conservation in Ceramic Industry”, sponsored by the United Nations Industrial Development Organization (UNIDO) and the Ministry of International Trade and Industry (MITI) of Japan, 1994, Chapter 3, page 11.

[2] http://www.takasago-inc.co.jp/eg/rhk/rhk.htm