Workshop on Industrial Applications

How is a hidden rule found from operation data?

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Steel company researchers tend to focus on manufacturing processes. The phenomena are mostly complex, however, observations are limited because we must operate with high temperature objects and large-scale equipment. Consequently, we have been trying to find hidden rules from operation data.

For example, we use blast furnaces in the main process of iron making. A blast furnace is a huge reactor with a height of about 40 meters. In this process, sintered ore and coke are sequentially charged from the top of the blast furnace while hot air is blasted from the furnace bottom at a temperature about 1500K. This raises the temperature inside the blast furnace to a high temperature of more than 2700K, thereby accelerating the chemical reaction that separates the iron from the sintered ore.

The temperature, measured with the thermo-couples in a brick, is shown in Figure 1. The section within a dotted frame shows abnormal conditions of operation control; this continued over a two-month period. Shutdown operations were carried out at the times shown by arrows in the figure. In shutdown operations, production of molten iron is suspended for one or two days. Although the primary purpose of shutdown operations is scheduled maintenance, unscheduled shutdown operations were carried out five times to lower the furnace temperature. These are enormously damaging in terms of cost. Why do such abnormal conditions suddenly occur? Is there an effective means of identifying the signs? These are the issues that concern us.

We also show a map representing the position of these phenomena in four categories of the manufacturing process: stationary, non-stationary, linear and nonlinear. Our phenomena fall into the non-stationary and nonlinear category. However, we don't have a method by which this area can be analyzed. If mathematical principals can be applied in this area, we can have direct linkage between real phenomena and mathematics. This will enable reduced costs, and innovation in manufacturing processes.

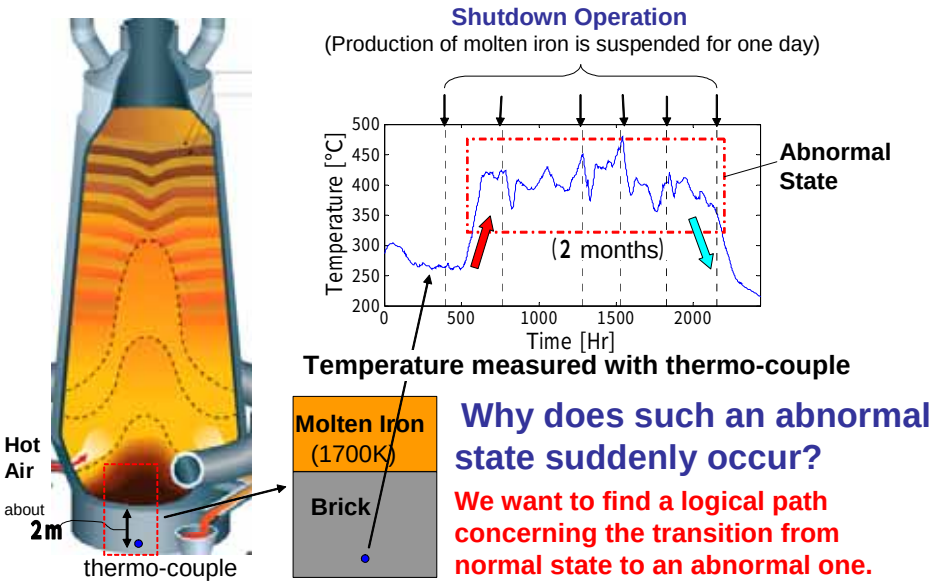

Figure 1 Problem description for blast furnace

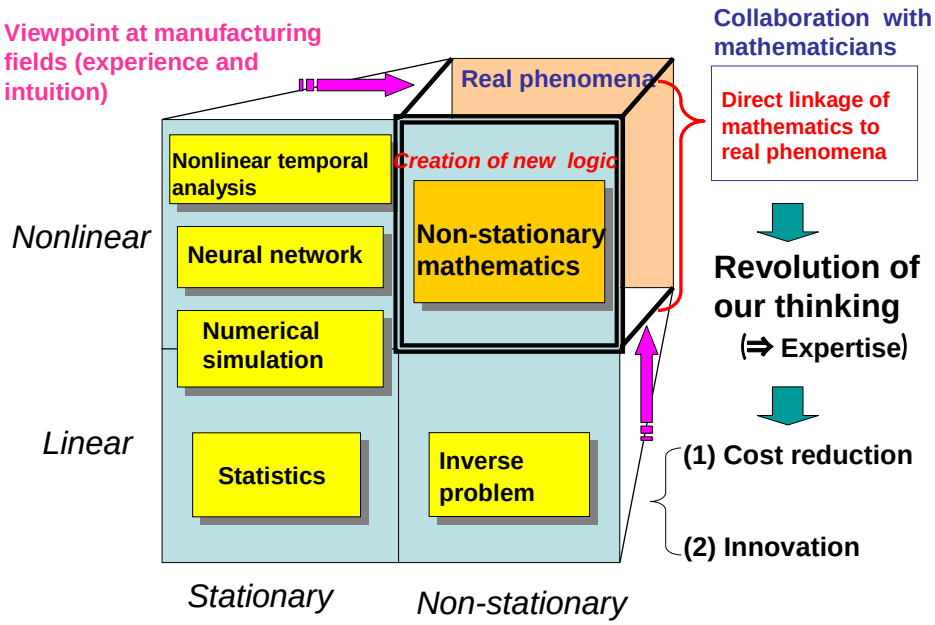

Figure2 Expectation regarding mathematics