Abstract:

The JFE Group has developed a high-temperature gasifying and direct-melting furnace as a completely

combustion furnace, not shown in the figure, is located next to the high-temperature gasifying and direct melting furnace. The introduction of oxygen-enriched air from the main tuyeres promotes high-temperature combustion in the high-temperature combustion and melting zone at the lower segment in the furnace, thus melting the non-combustible components of the wastes as slag. The slag can be tapped continuously, as shown in **Photo 1**. Continuous tapping is an extremely attractive feature for operators, as it reduces the operational load to far lower levels than can be expected with intermittent tapping. The introduction of air from the sub tuyeres and the combustion gas from the high-temperature combustion and melting zone maintain the combustion at a temperature of about 600°C in the partially fluidized gasifying and pyrolysis zone at the middle segment in the furnace, thus drying and pyrolyzing the wastes. The

(1) air temperature, (2) oxygen percentage, (3) total oxygen, (4) throughput of waste, and (5) coke ratio. The observation variables are (1) the temperature of the molten slag, (2) the height of the charged waste, and (3) the temperatures of the respective parts of the furnace. The control target is to keep the molten slag at a constant reference temperature. The long and variable residence time constitutes the biggest challenge in controlling the temperature of the molten slag, as the control action is not reflected immediately in the state and the system tends to overshoot and lose stability.

To avoid overshoots and instability, the system employs a method of rule-based control based on online model predictions, as shown in **Fig. 2**. In addition to the various kinds of present process values, the predicted values from the online dynamic model of the plant are taken into account.

3.3 Waste Tracking Model

Figure 3 is a conceptual diagram of a waste tracking model. The waste charged in for a specific period of time, for example, in 5 minutes, is treated as a cell or a layer. The weight (waste, coke, lime), percentage of each component (parts that can be dry-distilled, fixed carbon, moisture, and ash) and bulk density are taken into consideration as attributes of a cell. The weight can be actually measured when the waste is charged into the furnace, and the other values are treated as constants. The fixed carbon component at the bottom of the furnace loses volume mainly via oxidization. The ash component also loses volume, via melting in proportion to the oxidization. As a result of moisture evaporation, dry distillation, melting, and discharge at the main tuyere point, each cell loses volume and moves downward. The pile height is calculated from the thickness of each cell.

3.4 Heat Transfer Model

The waste charged in from the top descends from a partially fluidized gasifying and melting zone to a high-temperature combustion and melting zone. As it descends, it undergoes a heat exchange with the high-temperature gas traveling up through the furnace. As a result of this heat exchange, the temperature of the descending waste rises and the incombustible component melts.

This model of heat transfer in the countercurrent flow (**Fig. 4**) calculates the heat exchange of the charged waste, a coke layer, and high-temperature gas, and estimates and predicts the temperature of the waste and the coke layer.

The assumptions of this model are as follows:

- The gas flow is steady.
- The gas flow rate is constant at all points in the furnace.
- The specific heat of the waste is constant.
- The reaction at the main tuyere is described by $2C+O_2 \rightarrow 2CO$.
- All O_2 reacts at the main tuyere.
- The reaction at the sub tuyere is described by $2CO+O_2 \rightarrow 2CO_2$.
- The heat transfer coefficient in cells containing water differs from that in cells without water.

The model shown in Fig. 4 considers the heat exchange of the high-temperature gas and the cell with a height dz. As the velocity of the gas flow is quite high relative to the velocity of the waste flow, the gas temperature is treated as a function of height and only the

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Operation Results of the De[illegible]

Figure 8 shows the difference[illegible] with and without application of the[illegible] and vertical axes of Fig. 8 represen[illegible] perature and the frequency distrib[illegible] ture measured every 5 seconds f[illegible] As the figure shows, the frequency[illegible] as the temperature deviation shrin[illegible] Fig. 8 shows the results of the N[illegible]ated manually, and the middle graph sh[illegible] of the No. 2 furnace operated with the A[illegible]om graph shows the results of the No. 2 furna[illegible]ted manually four days after the operation plotte[illegible]e middle graph. In each case, the waste property was[illegible]asically the same. It turns out that the slag temperature distribution is smaller with ACC than with operator operation. The standard deviation of the slag temperature is 90.5 degrees with the ACC and 109.3 degrees without the ACC. Under the ACC control mode, the temperature remains high, at around 1 773 K, and continuous tapping was maintained perfectly without disruption. The results indicate that the ACC can stabilize the slag temperature and thereby reduce the workload of human operators.