# HOW TO DETERMINE THE EXTENT OF THE GAS-SOLID REACTIONS VIA EFFLUENT GAS ANALYSIS

**Elaf Abdulameer Taher Alsalihi**

**Engineering Faculty, Chemical Engineering Department, Çankırı Karatekin University, Çankırı, Türkiye**

**ORCID ID: 0000-0003-1712-2867**

**Nesibe Dilmaç\***

**Engineering Faculty, Chemical Engineering Department, Çankırı Karatekin University, Çankırı, Türkiye**

**ORCID ID: 0000-0003-3147-0155**

|  |
| --- |
| **ABSTRACT**  In this study, the method used for converting the effluent gas composition data into the extent of the gas-solid reaction was described. Specifically, the "direct reduction" reaction between the iron ore (containing Fe2O3) and H2 gas in a fluidized bed reactor was taken into account. As the first step, the reactive gas (H2) whose flow rate and composition were adjusted by a mass flow controller, was sent to the empty reactor in the absence of the solid reactant, and the composition of the effluent was recorded with an ABB EL 3020 simultaneous gas analyzer. In this way, a constant "base concentration" line that showed the value of the concentration at the outlet of the reactor in case no reaction occurred, was determined. Afterward, the procedure was repeated with the same H2 concentration for 5 g of iron ore in the reactor, and the composition of the effluent gas was recorded instantly by the analyzer. But this time, a time-dependent concentration curve -whose initial parts had low values due to the fast consumption of H2 by the reaction, while the last parts had higher values because of the declining reaction rate-, was obtained. The points constituted that curve corresponded to the "instantaneous unconsumed H2 " values. By subtracting the unconsumed values from the base values via Microsoft Excel®, the "instantaneous H2 consumption" curve of the reaction was obtained. Inserting the laboratory temperature, pressure, and the volumetric rate of gas flow rate into the ideal gas law, the curve was updated to show the molar amount of the consumed H2. As the last step, taking into account the reaction, and the stochiometry between Fe2O3 and H2, the instantaneous molar amount of the oxygen removed from the ore was calculated. As the extent of the direct reduction reaction is mostly defined as the ratio of the oxygen removed from the ore to the total amount of removable oxygen in the ore, the instantaneous reaction extent was calculated considering the oxygen content of the 5 g iron ore. By summing all the calculated instantaneous values, the final reduction degree achieved at the end of the experiment was determined [1,2,3].  **References:**  [1] Alsalihi E., *Menteş yöresi hematit cevherinin akışkan yatak reaktörde indirgenme kinetiğinin belirlenmesi*, MSc Thesis, Çankırı Karatekin University, Graduate School of Natural and Applied Sciences, 2022, 52 pages, Çankırı.  [2] Dilmaç, N., Yörük, S.,& Gülaboğlu, M.Ş. (2012). Determination of reduction degree of direct reduced iron via FT-IR spectroscopy, *Vibrational Spectroscopy*, 61, 25-29.  [3] Chen, H., Zheng, Z., Chen, Z., Bi, X.T. (2017). Reduction of hematite (Fe2O3) to metallic iron (Fe) by CO in a micro fluidized bed reaction analyzer: A multistep kinetics study, *Powder Technology*, 316, 410-420. |

# Keywords: Effluent gas analysis, Direct reduction, Gas-solid reactions, Iron ore, Hematite.

# \* Corresponding author. *e-mail address: ndilmac@karatekin.edu.tr*