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Effect of carbon on the sintering kinetics of a single hematite pellet

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1 INTRODUCTION

- Induration - green pellets are heated up-to 1350°C.
- During induration, pellets { physical change (sintering) / chemical change (oxidation/reduction)
- Sintering behaviour of magnetite pellet is different due to oxidation and non-stoichiometry at high temperatures.
- Carbon is added in the hematite pellet for internal heat generation but it brings a lot of simultaneous reactions associated with carbon burning.
- Need to understand the effect of carbon on material transportation during sintering.

2 METHODS

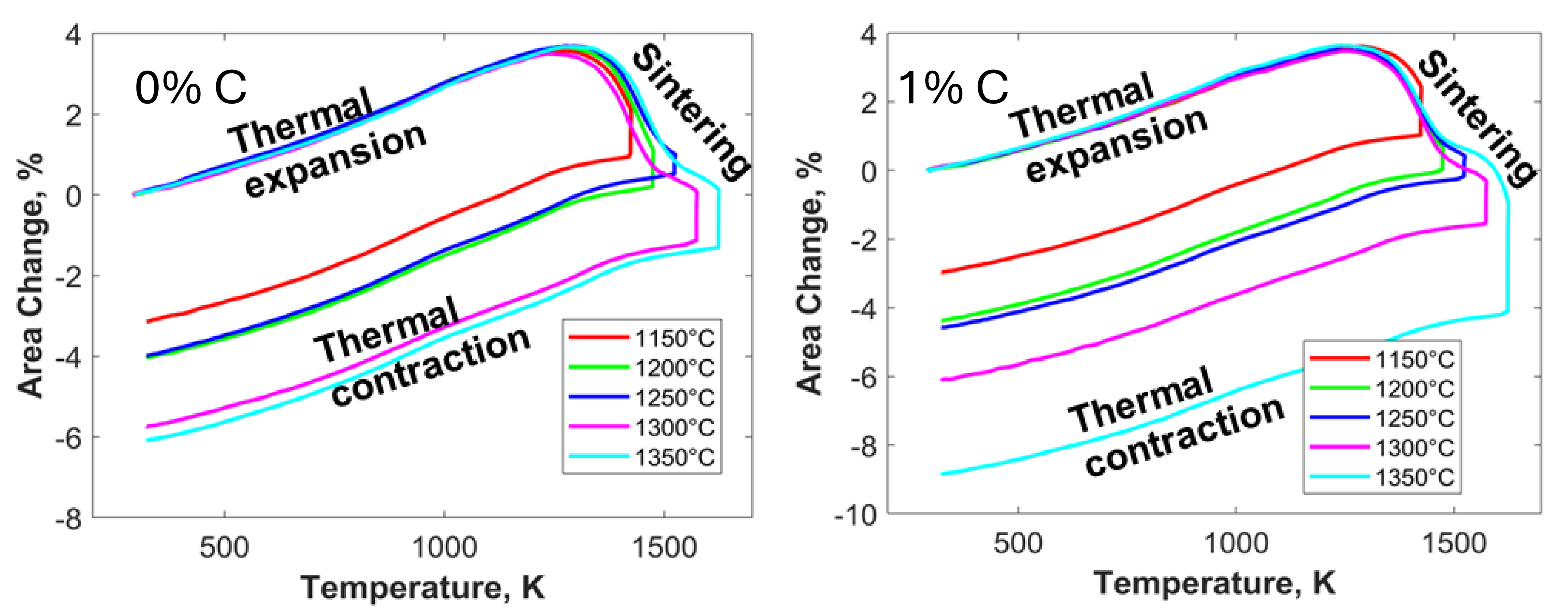
- The physical properties of the pellet (porosity & size) are chosen in a narrow range.
- Sintering experiments (optical dilatometer) { 0% coke / 1% coke(0.85% C)
- Sintering quantification $\gamma = \frac{\textit{Sintering already achieved}}{\textit{Sintering yet to be achieved}} = \frac{V_\circ - V}{V - V_{true}}$

$$\text{Sintering ratio } (\gamma) = \left(\frac{-\delta_{A,sintering}}{\delta_{A,true} - \delta_{A,sintering}}\right)$$

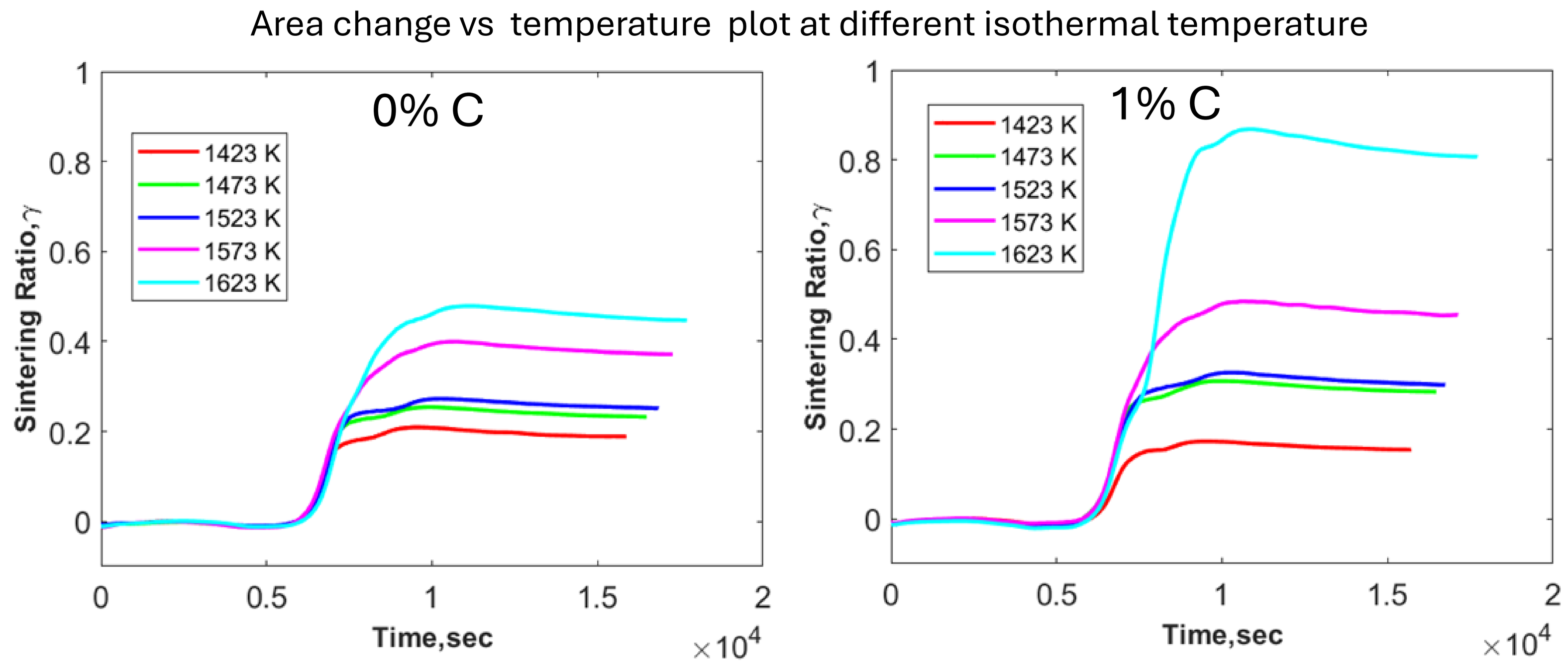
$$\text{Where, } \delta_{A,true} = \frac{2}{3}\left(\frac{\rho_o - \rho_{true}}{\rho_{true}}\right) * 100$$

Pellet	Sintering Temperature	Porosity		Heating Rate	Isothermal Hold Time
	K (°C)	0% Coke	1% coke	K/min (°C/min)	min
HP0 (0% coke) HP1 (1% coke)	1423 (1150) 1473(1200) 1523(1250) 1573(1300) 1623(1350)	28.63 31.59 29.56 31.05 29.07	30.74 31.21 29.07 30.54 29.41	10	20

3 RESULTS



Area change vs temperature plot at different isothermal temperature



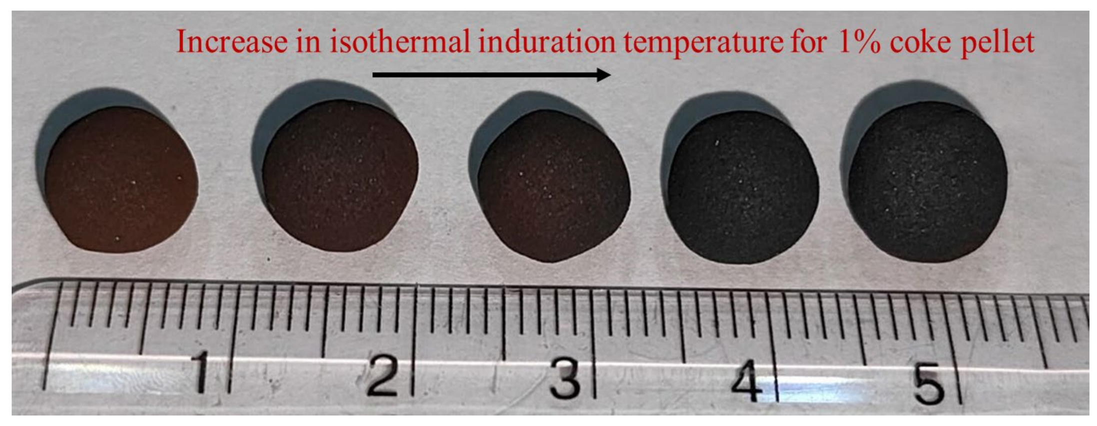
Sintering ratio vs time plot at different isothermal temperature

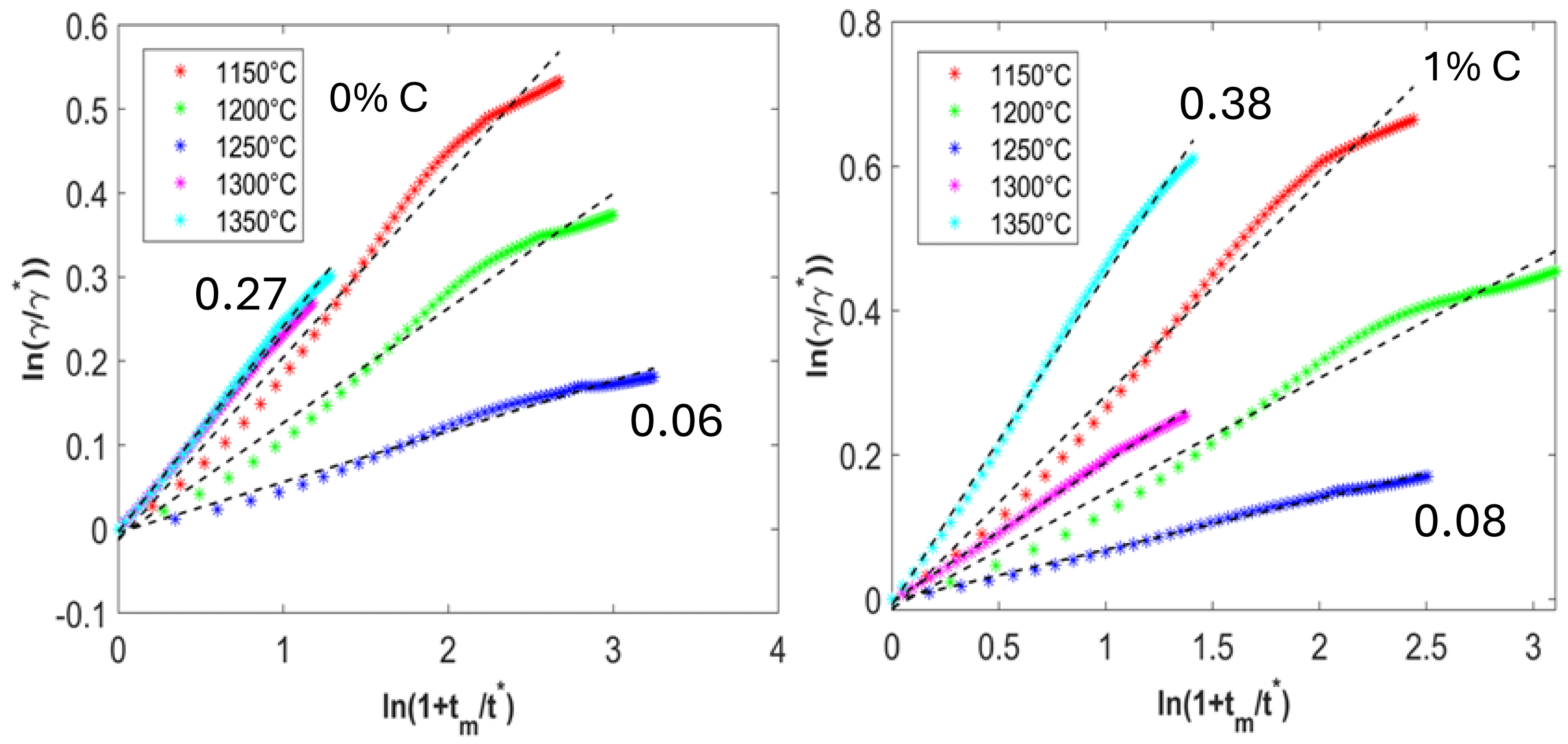
$$\gamma = kt^n$$

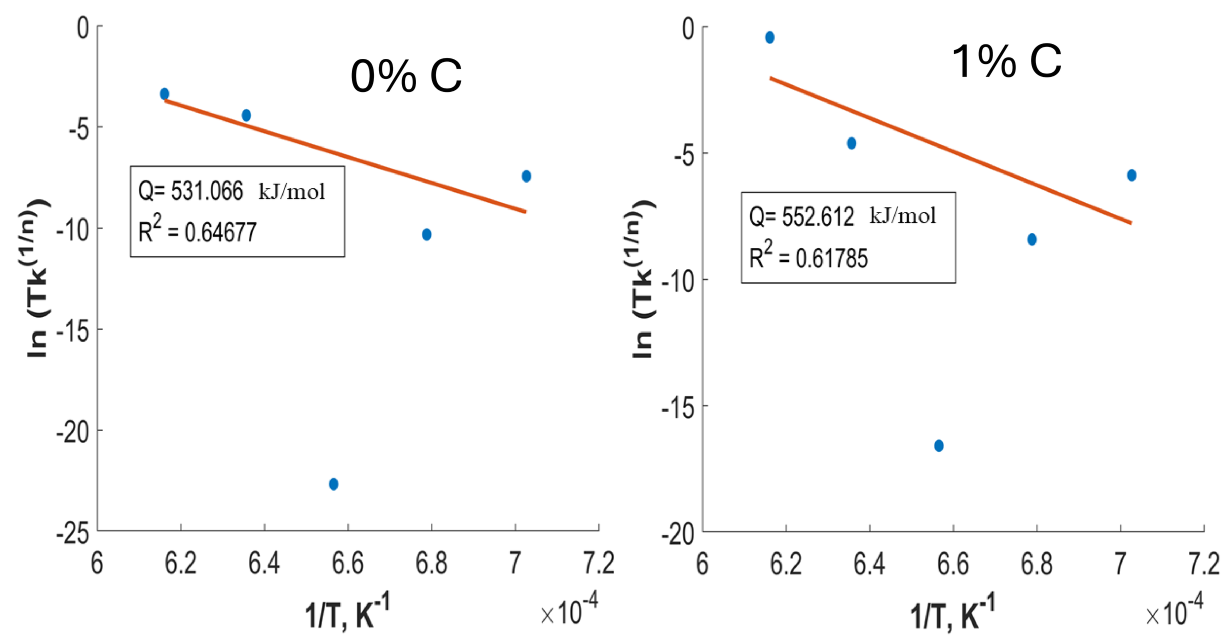
$$\gamma^* = k\,(t^*)^n$$

$$\gamma = k(t^* + t_m)^n$$

$$\ln\left(\frac{\gamma}{\gamma^*}\right) = n\ln\left(\frac{t^* + t_m}{t^*}\right)$$







Arrhenius plot for activation energy calculation

Literature [1-3]	Sintering Mechanism
1/7 (0.14)	Surface diffusion
1/6 (0.17)	Grain boundary diffusion
1/5 (0.20)	Volume diffusion
1/2 (0.5)	Viscous flow

4 DISCUSSION

An activation energies(AE) of 464 kJ/mol and 451 kJ/mol have been reported for oxidised magnetite pellet and magnetite pellets respectively. A high AE is attributed to the possibility of initial neck formation at bentonite/gangue minerals through reaction or solid-state diffusion [3-4]. Another possible mechanism for high AE, where the porosity is high and grain boundaries are low, the creation of point defect is too hard [5]. Considering the point defect model, an AE of 613kJ/mol is reported for iron diffusivity into interstitial [6].

5 CONCLUSION

- Power law equation can be used to study isothermal sintering kinetics.
- Sintering kinetics parameters, namely activation energy and time exponent 'n' is calculated. Depending upon these values kinetics mechanism can be assessed.
- The order of magnitude of AE is same for both compositions of pellet, although the amount of sintering achieved is more for 1% coke pellet.

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