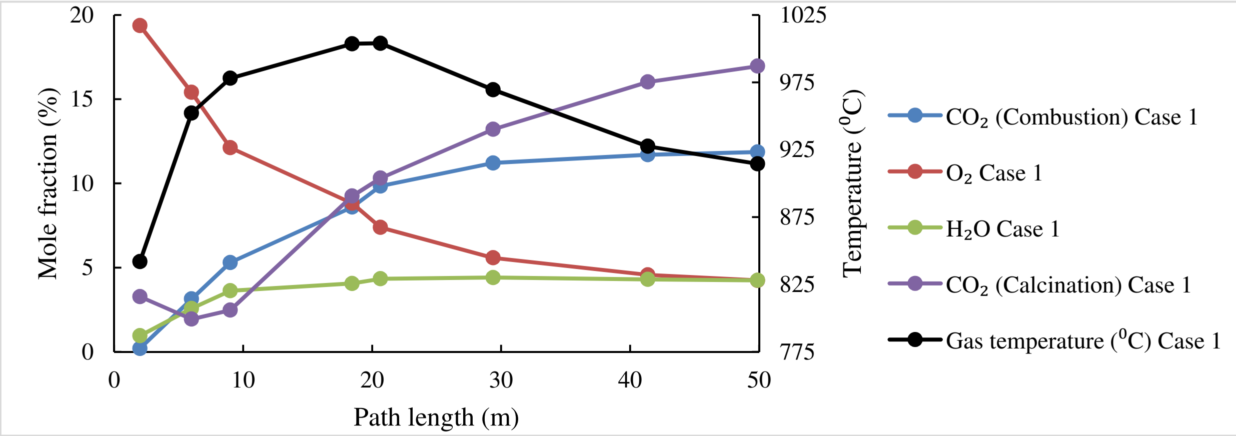
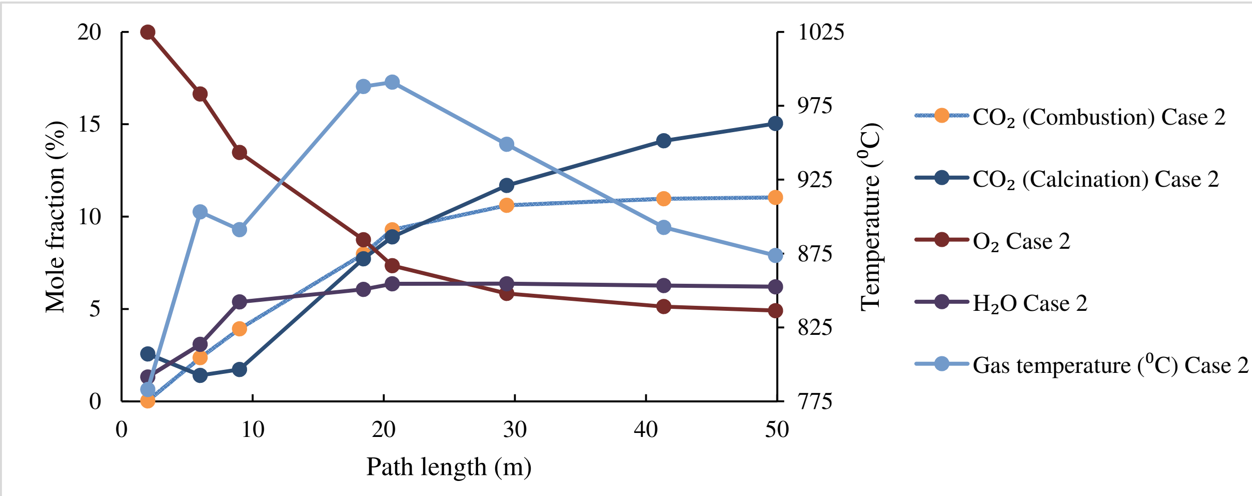


(a)



(b)

Figure 6. Variation of gas temperature and mole fraction of CO_2 (from calcination + combustion) O_2 and H_2O (a) for Case 1 (b) for Case 2

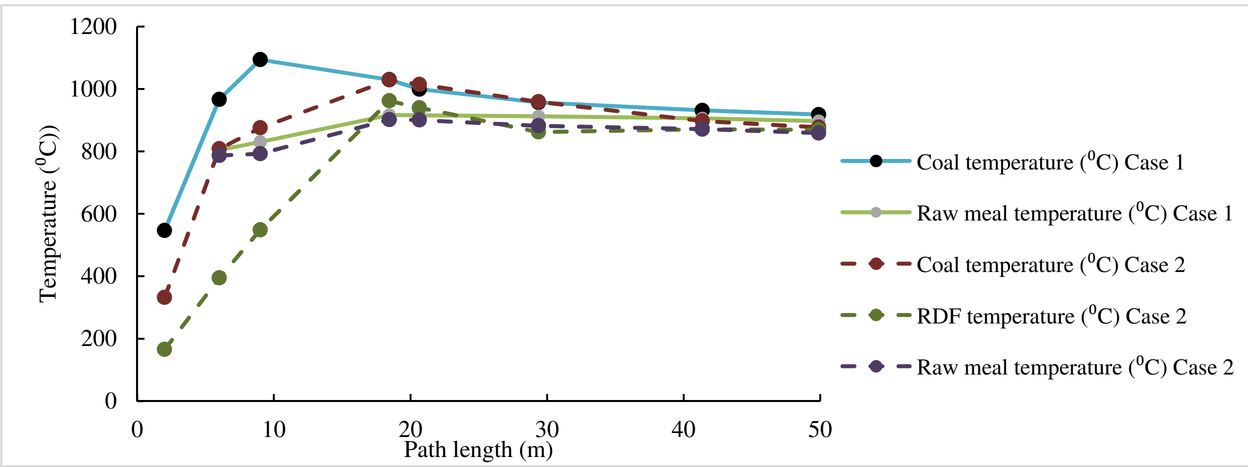


Figure 7. Temperature distribution of coal, raw meal and RDF for Case 1 and Case 2

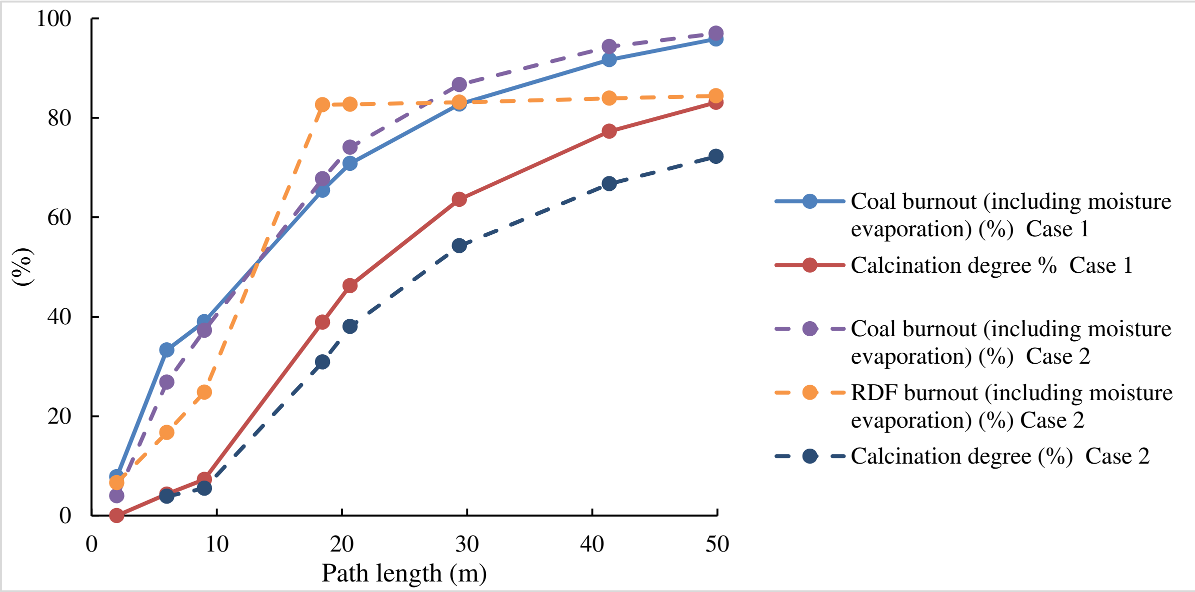


Figure 8. Calcination degree and fuel burnout for Case 1 and Case 2

Figure 8 shows the calcination degree and fuel burnout for both cases. Although the same energy was supplied in Case 1 and Case 2, the calcination degree is lower in the latter case. There are two reasons for this. The main reason is the high moisture content of RDF (see Figure 6), which reduces the particle temperature and gives a lower burnout of this fuel (see Figure 8).

Hence, less energy is released to support the decarbonation. This happens because in the initial stage, energy is spent on evaporating the moisture. A consequence of this is that RDF char burning takes place later, i.e. more downstream along the path length. In addition, since the RDF particles are bigger, it takes more time to reach complete combustion.

Conclusion

In this study CFD tool has been applied to get detailed information about temperatures, calcination degree and fuel burnout in a precalciner system. Even if the fuel energy supply is not changed, replacing part of the coal with RDF reduces the calcination degree in the process, which can be seen as quality reduction in precalcined meal. The reason for the reduced calcination degree is the poorer burnout of the RDF particles caused by higher moisture content and larger particles. The method applied in this study can be used to evaluate the calcination process under different process conditions and to optimize the process when coal is replaced by other alternative fuels with different characteristics.

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Financial support from Telemark Fylkeskommune is greatly acknowledged, as is the support from the Norwegian Research Council through the project "Optimised and increased use of Refuse Derived Fuel as substitute for coal at Norcem Brevik cement plant" (BIA project 245690).

Nomenclature

ρ	Gas density (kgm^{-3})
$\vec{v}$	Gas velocity vector (ms^{-1})
S_m	Mass source ($kgm^{-3}s^{-1}$)
p	Static pressure (Nm^{-2})
$\bar{\bar{\tau}}$	Stress tenser (Nm^{-2})
$\vec{g}$	Acceleration of gravity (ms^{-2})
$\vec{F}$	External body force (N)
μ	Molecular viscosity ($kgm^{-1}s^{-1}$)
I	Unit tensor
E	Total energy (m^2s^{-2})
k_{eff}	Effective conductivity ($Wm^{-1}K^{-1}$)
T	Gas temperature (K)
h_j	The enthalpy formation of species j (Jkg^{-1})
$\vec{J}_j$	Diffusion flux of species j ($kgm^{-2}s^{-1}$)
$\overline{\overline{\tau_{eff}}}$	Viscous dissipation term
S_h	Source of energy ($kgm^{-1}s^{-3}$)
$\vec{u}_p$	Particle velocity vector (ms^{-1})
F_D	Drag force on particle (s^{-1})
ρ_p	Particle density (kgm^{-3})
d_p	Particle diameter (m)
C_D	Drag coefficient
Re	Particle Reynold number
m_p	Particle mass (kg)
k	Devolatilisation reaction rates constant
$f_{v,o}$	Initial volatile fraction in fuel particle (%)
$f_{w,o}$	Initial moisture fraction in particle (%)
$m_{p,o}$	Particle initial weight (kg)

A_1	Pre exponential factor for k
E_1	Activation energy for k (Jkmol^{-1})
A_p	Surface area of particle (m^{-2})
T_∞	Local temperature of continuous phase (K)
p_{ox}	Partial pressure of oxidant (Nm^{-2})
D_o	Diffusion rate coefficient (m^{-1})
R	Universal gas constant (Jkmol^{-1}K^{-1})
c_p	Heat capacity of particle (Jkg^{-1}K^{-1})
h	Convection heat transfer coefficient (Wm^{-2}K^{-1})
h_{fg}	Latent heat of devolatilisation (Jkg^{-1})
ϵ_p	Particle emissivity
σ	Stefan-Boltzmann constant (5.67 x 10^{-8} Wm^{-2}K^{-4})
θ_R	Radiation temperature (K)
f_h	Particle absorb energy fraction from char combustion
H_{rec}	Heat release by the char combustion (Jkg^{-1})

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