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Effect of Calcium Carbonate on the Reduction Behaviour of Mill Scale

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Abstract

MillScale is a waste cum by-product obtained during hot rolling process. Millscale consists of iron and its oxides. This study shows the condition of mill scale reduction, a by-product of iron and steel formed during hot rolling of steels, with low grade coal to produce iron powder. In this paper an attempt has been made to study of effect of addition of calcium carbonate on reduction behavior of millscale. The reduction was carried out at 900°C for 90 minutes with varying amount of Calcium Carbonate powder (reducing atmosphere). An elaborated thermal and reduction kinetics were understood for the reduction temperature Simple XRD and degree of reduction was calculated. It was found out that with addition of calcium carbonate reduction increases upto a limit and then decreases. The maximum iron content was found in sample containing 10% by weight calcium carbonate of mill scale.

Keywords: Millscale, Limestone and Low grade coal

1. Introduction

Until last decade, solid waste produced by integrated steel and iron plant was call “Waste”, but now this term is replaced by “By- Product” due to intrinsicre utilization of these wastes. Millscale which is a solid by-product of steel making industry during hot rolling contains metal liciron, and its oxides like Wustite (FeO), Hematite (Fe_2O_3) and Magnetite (Fe_3O_4) along with traces of non-ferrous metals, alkaline compounds and oils from rolling process. During the direct reduction process oxygen associated with iron oxide is reduced by using suitable reducing agent to give sponge iron or iron powder. The reduction of millscale allows the use and development of new materials like sponge iron or iron powder that can be reused in the electric furnace as metallic load in steel manufacturing or as raw materials in the production of iron base powder metallurgy parts.[1-3]

2. Raw materials

Raw materials used during reduction of millscale are Millscale, Lowgrade coal and Limestone.

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These raw materials were easily available in local area at reasonable cost, so the overall process is economically feasible[4-6]. The source of raw material with their price index shown in table 2.1

Table 1. Raw material used in experiment with their price index and source.

RawMaterials	Price (INR/Kg)	Source
Mill Scale	5.00to7.00	SARADA Enterprises,a hot rolling mill in Jaipur
Low Grade Coal	1.50to4.00	Matasuhk Coalmines, Nagaur district, Rajasthan
Lime stone	10.00to 15.00	Local market, Jaipur

2.1. Proximate analysis of coal

According to proximate analysis of coal done by Indian School of Mines, Dhanbad and also verified with the data mentioned on Rajasthan State Mines and Minerals Ltd.., shown in table2.1, the fixed carbon content is 26.68%, which is the main source of heat generation during reduction process. The proximate analysis of coal is shown below.

Table 2. Proximate Analysis of Coal

Parameter	Lignite Coal (wt%)
Fixed Carbon	26.68
Ash	9
Volatile Matter	25.26
Other Components	39.06

3. Direct reduction process

Sponge iron or iron powder can be produced from iron bearing raw material by two different process: Coal based and Gas based reduction process. The most reducing agent for iron oxide reduction are CO, H_2 and mixture of these two gases.[4] From literature survey and experimental work it was found that, reduction of iron or iron bearing material like millscale increases with increase in temperature and time and later reduction becomes constant. Calcium carbonate (lime or dolomite also) mixed with coal which works as catalyst and helps in scavenging the sulphur.

4. Reduction conditions

Reduction is carried out in a muffle furnace maintained at 900°C for about 90 minutes, with varying the amount of Ca CO_3(0%, 5%,10%, 15% Wt. of millscale).The size of millscale, limestone powder and coal powder taken is 150 micron and the weight of mill scale to that of (Coal+ Lime) is in the ratio1:1.

5. Reduction kinetics and thermo dynamics

The reactions that take place during reduction of millscale in the crucible are as follows

$CaCO_3=CaO+ CO_2(g)$

$C(s)+CO_2(g)\rightarrow 2CO(g)$

$3Fe_2O_3+CO=2Fe_3O_4+CO_2$

$Fe_3O_4+CO=3FeO+CO_2$

$FeO+ CO=Fe+ CO_2,$

$Fe_2O_3+ 3CO=2Fe+ 3CO_2$

The specific heats of an element or compound is given by formula [7]

$$C_p=A+ B*10^{6}T^{-2}+ C*10^{-3}T+ D*10^{-6}T^{2}+ E*10^{-9}T^{3}J/K/mol---[1]$$