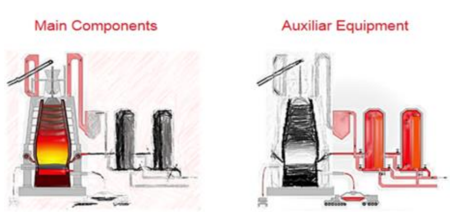
BLAST FURNACE

060110410 CEREN YAĞŞİ
060110405 DİLAY KİBAROĞLU
060120549 ÖZGE NUR ÜNLÜ
060120516 OSMAN ÇAĞLAR BAYSALLI
060100913 NERGİZ ALİYEVA
060110406 BİRSEN BAŞ
060120503 BERİL SAADET YENİGÜL
060140707 ELİF ÖZKAN
060100306 MUSTAFA ÖZDEMİR
060130712 ANIL UZER

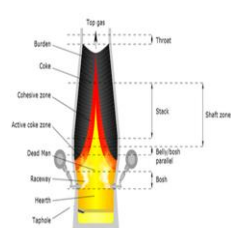
INTRODUCTION TO BLAST FURNACE

* THE PURPOSE OF A BLAST FURNACE IS TO CHEMICALLY REDUCE AND PHYSICALLY CONVERT IRON OXIDES INTO LIQUID IRON CALLED HOT METAL. THIS PARTICULAR PROCESS IS THE DOMINATING IRONMAKING ROUTE FOR PROVIDING THE RAW MATERIALS FOR STEELMAKING.

ZONES OF THE BLAST FURNACE



ZONES OF BLAST FURNACE MAIN COMPONENTS



THROAT: THE BURDEN SURFACE AT THE TOP OF THE BLAST FURNACE

SHAFT: WHERE THE ORES ARE HEATED AND REDUCTION REACTIONS START

BELLY OR BOSH PARALLEL: THE SHORT VERTICAL SECTION

BOSH: THE ORE REDUCTION COMPLETES, AND THE ORES ARE MELTING DOWN

HEARTH: WHERE THE MOLTEN MATERIALS ARE COLLECTED AND TAPPED VIA THE TAP-HOLES

ZONES OF BLAST FURNACE MAIN COMPONENTS

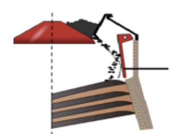
SCHEMATIC VIEW OF TUYERES AND BUSTLE PIPE

TUYERES AND BUSTLE PIPE:
THE BUSTLE PIPE IS A LARGE DIAMETER DOUGHNUT SHAPE PIPE ENCIRCLING THE FURNACE. IT FEEDS HOT AIR TO THE TUYERS THE TEMPERATURES OF THE HOT BLAST RANGE FROM 900 °C TO 1250 °C.

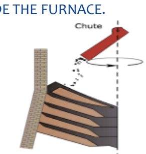
ZONES OF BLAST FURNACE AUXILIAR COMPONENTS

CHARCING SYSTEM

THE MATERIALS USUALLY HELD IN HOPPERS AT THE TOP OF THE FURNACE UNTIL A CHARGE, USUALLY CONSISTING OF SOME TYPE OF METALLIC, COKE AND FLUX HAVE ACCUMULATED. THE PRECISE FILLING ORDER IS DEVELOPED BY THE BLAST FURNACE OPERATORS CARREFULLY CONTROL GAS FLOW AND CHEMICAL REACTIONS INSIDE THE FURNACE.



DOUBLE BELL CHARGING

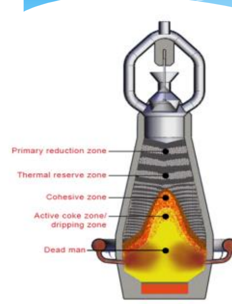


BELL LESS TOP CHARGING

ZONES OF BLAST FURNACE AUXILIAR COMPONENTS

HOPPERS:FOR TEMPORARILY STORING THESE RAW MATERIALS
BELT CONVEYORS: FOR TRANSPORTING RAW MATERIALS TO THE FURNACE TOP
BF-TOP PRESSURE RECOVERY TRIBUNE: A BF USUALLY OPERATED WITH A FURNACE TOP PRESSURE OF ABOUT 250 KPA. THE RECOVER THE ENERGY FROM THE LARGE VOLUME OF HIGH PRESSURE EXHAUST GAS , THE BF IS EQUIPPED, AFTER DUST REMOVAL , WITH TOP PRESSURE RECOVERY TRIBUNE (TRT) FOR GENERATING ELECTRIC POWER BY UTILIZING THE PRESSURE DIFFERENCES BETWEEN THE FURNACE TOP AND GAS STORING HOLDER.
DUST REMOVAL: EQUIPMENT FOR DUST REMOVAL AND RECOVERY.
CASTHOUSE: WHERE THE MOLDEN IRON AND REMAINING SLAG SEPERATED BEFORE THE IRON IS PURED INTO TORPEDO CAR OR LADLE FOR TRANSPORT TO FURTHER REFINEMENT.

ZONES OF BLAST FURNACE

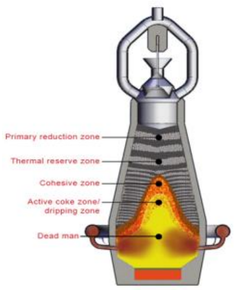


PRIMARY REDUCTION ZONE:
THE UPPER PART OF SHAFT, WHERE HIGHER VALENCY IRON OXIDES ARE REDUCED. TEMPERATURE RANGES FROM 400 °C TO 1000 °C

THERMAL RESERVE ZONE:
THE LOWER PART OF THE SHAFT ZONE, WHERE THE TEMPERATURE IS MAINTAINED AT ABOUT 1000-1200 °C. IN THIS ZONE, REDUCTION OF WUSTITE TO METALLIC IRON TAKES PLACE

COHESIVE ZONE:
EXTENDS FROM ABOVE BOSH NEAR THE WALL UP TO MIDDLE PART OF STACK IN THE CENTER OF THE BF. THE MATERIALS HAS REACHED ABOUT 1200 °C START TO SOFT EN AND MELT EXCEPT COKE PARTICLES

ZONES OF BLAST FURNACE



ACTIVE COKE ZONE:
BENEATH THE COHESIVE ZONE, WHERE THE FINAL REDUCTION TO METALLIC IRON COMPLETES, MELTS OF SLAG AND HOT METAL FROM AND DRIP THOUGH THE COKE LAYER

DEAD MAN:
A POROUS PACKED-BED OF UNREACTED COKE PARTICLES SITTING OR FLOATING IN THE HEARTH. CARBURIZATION OF HOT METAL TAKE PLACE WIHTIN THE DEAD MAN

CHEMICAL REACTIONS

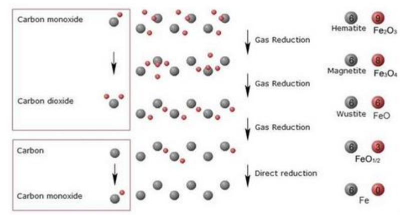


ILLUSTRATION FOR PROCESS OF CONVERTING FROM HEMATITE TO METALLIC IRON

CHEMICAL REACTIONS DIRECT REDUCTION

1) $FeO + CO = Fe + CO_2$

2) $CO_2 + C = 2CO$

TOTAL: $FeO + C = Fe + CO$

DIRECT REDUCTION USES CARBON AS THE REDUCTANT AND GENERATES EXTRA CO GAS; DIRECT REDUCTION COSTS A LOT OF ENERGY

CHEMICAL REACTIONS INDIRECT REDUCTION

IT IS ALSO CALLED GAS REDUCTION. GAS REDUCTION TAKES PLACE BETWEEN THE CO OF H_2 WITH SOLID BURDEN MATERIALS OF IRON OXIDES. IT REMOVES ABOUT 2/3 OF THE TOTAL OXYGEN IN THE IRON ORE. THE INDIRECT REDUCTION REACTIONS WITH CO ARE;

HEMATITE: $3Fe_2O_3 + CO = 2\,Fe_3O_4 + CO_2$

MAGNETITE: $Fe_3O_4 + CO = 3FeO + CO_2$

WUSTITE: $2FeO + CO = 2FeO_{0.5} + CO_2$

PULVERIZED COAL INJECTION

- THE INJECTION OF AUXILIARY REDUCTANTS SUCH AS COAL, OIL AND NATURAL GAS IS USED TO LOWER THE COST OF HOT METAL. COAL IS THE MOST COMMONLY USED AND ALLOWS COST SAVINGS AND HIGHER BLAST TEMPERATURES. COAL INJECTION LEADS TO INCREASED PRODUCTIVITY FROM USING OXYGEN ENRICHED BLAST
- COAL INJECTION IS CATEGORISED BY THEIR VOLATILE MATTER CONTENT 6-12% IS CLASSIFIED AS LOW VOLATILE, 12-30% AS MID VOLATILE AND OVER 30% AS HIGH VOLATILE COAL

HOT METAL PRETREATMENT

THE PROCESS IN WHICH IMPURITIES ARE REMOVED FROM THE HOT METAL BEFORE BOS ARE CALLED HOT METAL PRETREATMENT, AT PRESENT, AN INTEGRATED PROCESS OF SMELTING IN THE BF, HOT METAL PRETREATMENT, DECARBURIZING IN THE BOS, AND THE SECONDARY REFINING HAS BECOME THE STANDART MANUFACTURING PROCESS FOR HIGH GRADE STEELS.

HOT METAL PRETREATMENT

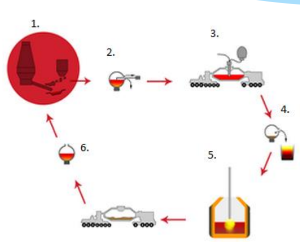
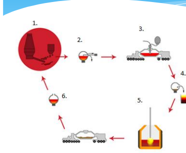


ILLUSTRATION FOR HOT METAL PRETREATMENT

HOT METAL PRETREATMENT



1.DESILICONIZATION: IS THEREFORE CONDUCTED AS A PRETREATMENT PROCESS BY ADDING IRON OXIDES SUCH AS MILL SCALE AND SINTERED ORE FINES TO HOT METAL IN THE RUNNERS IN THE CASTHOUSE OF THE BF OR IN THE TRANSFER VESSEL

2.SLAG SEPERATION

3.DEPHOSPHORIZATION: IS USUALLY CARRIED OUT AFTER DESILICONIZATION REACTION PROCEEDS MORE QUICKLY AT LOWER SILICON CONTENTS.

4.SLAG SEPERATION

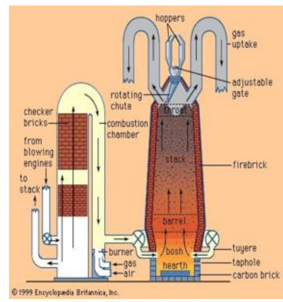
5.DECARBURIZATION

6.SLAG RECYCLING

RAW MATERIAL

ORE AND COKE; TO PRODUCE ONE TONNE OF HOT METAL A TOTAL OF ABOUT 1,600 IRON BEARING AS SINTERED ORE, LUMP ORE AND PELLETS ARE REQUIRED AND IT CONSUMES ABOUT 380 KG OF COKE AS THE REDUCTANT. THE ORE AND COKE ARE CHARGED IN ALTERNATE LAYERS FROM THE TOP OF THE BF.

HOT BLAST



APPROXIMATELY 1000 Nm3/tonne HOT METAL OF HOT BLAST IS ALSO BLOWN THROUGH THE TUYERES AFTER PREHEATING TO 1150- 1250 °C AT THE HOT STOVES. THE HUMIDITY AND THE OXYGEN CONCENTRATION OF THE HOT BLAST ARE ALSO CONTROLLED.

SINTERING AND COLD STRENGTH

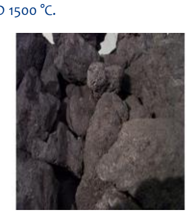
SINTER IS A METHOD OF FUSING IRON ORE FINES INTO THE PARTICLES SUITABLE FOR CHARGING INTO THE BLAST FURNACE. THE LIME (CACO3 ,CAO) IN THE SINTER IS ADDED AS A FLUX TO THE BLAST FURNACE AND SINTER IS CATEGORIZED. MEAN SINTER SIZES RANGE FROM 15 TO 25 MM AT THE SINTER PLANT.

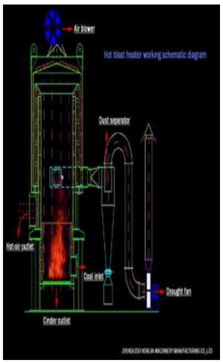
COLD STRENGTH
LOW COLD STRENGTH RESULTS IN A HIGH FINES RATE.

MELTING PROPERTIES AND COKE

MELTING PROPERTIES
THE MELTING OF SINTER IS DETERMINED BY THE CHEMICAL COMPOSITION. SINTER START SOFTENING AND MELTING AT 1200-1250 °C. VERY BASIC SINTER MELTS AT HIGHER TEMPERATURES OF 1300 C AND IF THE FeO CONTENT IS VERY LOW , MELTING TEMPERATURES CAN EXCEED 1500 °C.

COKE
SINCE THE 18TH CENTURY COKE HAS BEEN AS THE MOST IMPORTANT CARBON SOURCE IN THE BF PROCESS. SINCE THE 1960'S PART OF THE COKE USED HAS BEEN REPLACED BY AUXILIARY REDUCTANTS INJECTED THROUGHT THE TUYERES SUCH AS OIL, TAR, COAL AND NATURAL GAS .

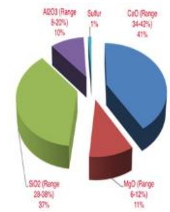




- THE AIR BLOW INTO THE BLAST FURNACE IS PRE-HEATED TO 100-1250 °C IN THE HOT BLAST STOVES. THE STOVES WORK IN CYCLES, FIRST THE REFRACTORY BRICKS IN STOVE ARE HEATED BY BURNERS USING BF GAS. THEN THE COLD BLAST BLOWN IN AND THE HEAT STORED IN THE BRICKS IS TRANSFERRED TO THE GAS. THE HOT BLAST IS DELIVERED TO THE BF VIA A HOT BLAST MAIN, BUSTLE PIPE AND THE TUYERES.
- AT THE TOP OF THE FURNACE THE BLAST FURNACE GAS IS HOT AND CONTAINS A LARGE AMOUNT OF FINE PARTICLES. TO REMOVE THESE, THE GAS IS LEAD VIA DOWNCOMER TO A DUST CATCHER AND WET CLEANING SYSTEM.

OUTPUTS

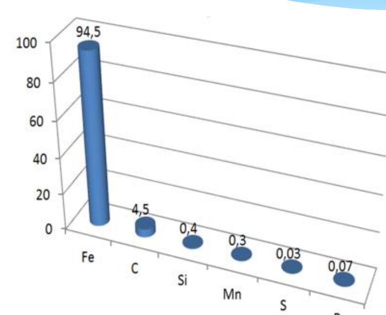
- SLAG IS FORMED THE GANGUE MATERIALS OF THE BURDEN AND THE ASHES OF THE COKE AND OTHER AUXILIARY REDUCTANTS. DURING BF PROCESS, PRIMARY SLAG DEVELOPS TO A FINAL SLAG.
- FOR MAIN COMPONENTS; SILICON DIOXIDE, CALCIUM OXIDE, MAGNESIUM OXIDE AND ALUMINUM OXIDE MAKE UP ABOUT 96% OF THE SLAG.
- THE MINOR COMPONENTS ARE MAGNESIUM OXIDE, TITANIUM DIOXIDE, POTASIUM OXIDE, SODIUM OXIDE, SULFUR AND PHOSPHORUS.



HOT METAL IS THE MAIN PRODUCT OF THE BF PROCESS. IT IS CARBON SATURAED IRON WITH A NUMBER OF IMPURITIES SUCH AS SILICON, MANGENESE, SULFUR AND PHOSPHOROUS. IT IS TAPPED FROM THE BF HEARTH AT A TEMPERATURE BETWEEN 1480-1520 °C. A TYPICAL COMPSITION OF HOT METAL CAN BE SEEN IN THE TABLE.

Table: Chemical Composition of Hot Metal

Element		Typical (wt%)
Iron	Fe	94.5
Carbon	C	4.5
Silicon	Si	0.40
Manganese	Mn	0.30
Sulfur	S	0.03
Phosphorus	P	0.07



THE REDUCTION OF IRON ORE BY CARBON AND HYDROGEN GASES IS A VERY COMPLICATED PROCESS. FOR A BETTER UNDERSTANDING OF THE FACTORS INFLUENCING THE REDUCIBILITY OF THE ORES, SINTERS AND PELLETS, HERE IS A VERY SIMPLIFIED VIEW OF RATE-CONTROLLING REACTIONS. IN MOST CASES, THE IRON ORE IS IN THE HEMATITE FORM AND REDUCTION STARTS FROM HEMATITE AND PROCEED IN THE FOLLOWING ORDERS;

HEMATITE→MAGNETITE→WUSTITE→METALLIC IRON

HEMATITE: $3Fe_2O_3 + CO = 2 Fe_3O_4 + CO_2$

WHEN THE COKE AND HEMATITE IS HEATED AND REACTS WITH CARBON MONOXIDE , IT IS TRANSFORM TO MAGNETITE. CARBONDIOXIDE AND WATER WHICH EVAPORATES INSTANTLY.

MAGNETITE: $Fe_3O_4 + CO = 3FeO + CO_2$

MAGNETITE TURNS INTO WUSTITE.

WUSTITE: $2FeO + CO = 2FeO_{0.5} + CO_2$

WUSTITE TURNS INTO METALLIC IRON

CONTROL ARCHITECTURE LAYOUT

LEVEL 0: FIELD INSTRUMENTATION

LEVEL 1: PROGRAMMABLE LOGIC CONTROLLER (PLC) AND/OR DISTRIBUTED CONTROL SYSTEM (DSC)
SQUNCING, LOGICAL CONTROL AND ALARMING

LEVEL 2: PC SYSTEM AND WORKSTATIONS
ONLINE MODELING, OFF-LINE MODEL AND SUPERVISORY CONTROL

LEVEL 3:MAINFRAME
PLANT INFORMATION SYSTEM

BLOWING IN PROCESS

THE PROCESS OF STARTING A BLAST FURNACE IS CALLED BLOWING IN AND IS MADE UP OF SEVERAL STEPS:

1) DRYING
2) FILLING
3) LIGHTING

BLOWING OUT PROCEDURE

1)DURING BLOWING DOWN THE FURNACE IS OPERATED WITHOUT CHARGING UNTIL THE BURDEN LEVEL REACHES APP. THE TUYERE LEVEL.
2)WATER SPREYS ARE INSTALLED AT THE TOP OF THE FURNACE TO CONTROL THE TOP GAS TEMPERATURE AND ONE OR MORE LEVELS OF STEAM SPRAYS ARE INSTALLED ON LOWER LEVELS FOR COOLING AND MAINTANM THE PRESSURE.
3)THE STEAM SPRAYS ARE ACTIVATED WHEN THE BURDEN LEVEL HAS PASSED.
4) THE BLAST RATE AND TEMPERATURE REDUCED AS THE BURDEN LEVEL LOWERS TO CONTROL THE TOP GAS TEMPERATURE AND ITS OXYGEN AND HYDROGEN CONTENT.
5)FINALLY DRAINING THE SALAMANDER. THE SALAMANDER IS THE IRON PRESENT IN THE HEART BELOW THE TOP HOLES AND IS USUALLY DRAINIED. IF PERMITTED TO SOLIDIFY, BLASTING IS REQUIRED TO REMOVE THE CHUNK OF SOLID IRON. THE SALAMANDER IS TAPPED THROUHT A HOLE IN THE BRICKWORK OF THE FURNACE BOTTOM CREATED BY DRILLING AND THE LAST PART WITH AN OXYGEN LANCE.

IRREGULARITIES OPERTATION

DURING BLAST FURNACE OPERATION IRREGULARITIES CAN OCCUR; CAUSING CONSIDERABLE CONCERN AND CAN LEAD TO SERIOUS TROUBLE IF NOT HANDLED CORRECTLY. THE MOST COMMON IRREGULATIES OCCURING ARE:

1)SLIP

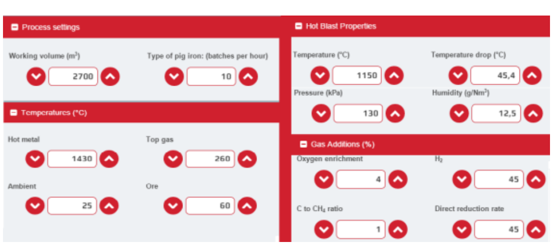
2)SCAFFOLDING

3)CAHNNELING

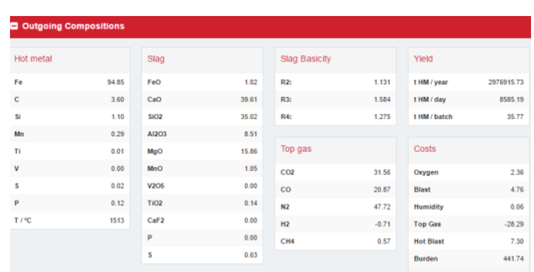
STEEL UNIVERSITY

FUEL AND FLUX

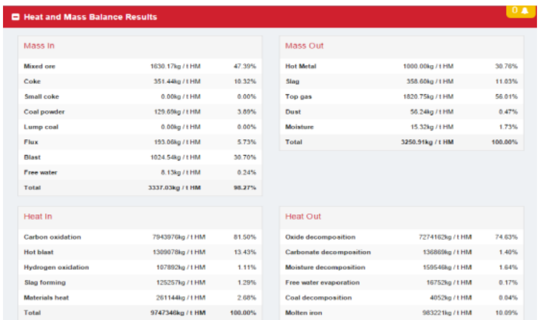
OTHER PROPERTIES



OUTGOING COMPOSITION



HEAT AND MASS BALANCE



Heat and Mass Balance Results

Mass In

Mixed ore	1630.17kg / t HM	47.39%
Coke	351.44kg / t HM	10.32%
Small coke	0.00kg / t HM	0.00%
Coal powder	129.69kg / t HM	3.89%
Lump coal	0.00kg / t HM	0.00%
Flux	193.06kg / t HM	5.73%
Blast	1024.54kg / t HM	30.70%
Free water	8.13kg / t HM	0.24%
Total	3337.03kg / t HM	98.27%

Mass Out

Hot Metal	1000.00kg / t HM	30.76%
Slag	358.60kg / t HM	11.03%
Top gas	1820.75kg / t HM	56.01%
Dust	56.24kg / t HM	0.47%
Moisture	15.32kg / t HM	1.73%
Total	3250.91kg / t HM	100.00%

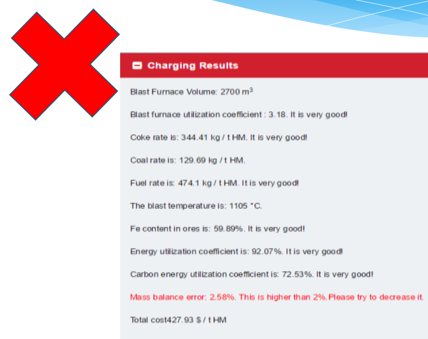
Heat In

Carbon oxidation	7943976kg / t HM	81.50%
Hot blast	1309078kg / t HM	13.43%
Hydrogen oxidation	107892kg / t HM	1.11%
Slag forming	125257kg / t HM	1.29%
Materials heat	261144kg / t HM	2.68%
Total	9747346kg / t HM	100.00%

Heat Out

Oxide decomposition	7274162kg / t HM	74.63%
Carbonate decomposition	136869kg / t HM	1.40%
Moisture decomposition	159546kg / t HM	1.64%
Free water evaporation	16752kg / t HM	0.17%
Coal decomposition	4052kg / t HM	0.04%
Molten iron	983221kg / t HM	10.09%

CHARGING RESULTS



Charging Results

Blast Furnace Volume: 2700 m^3

Blast furnace utilization coefficient : 3.18. It is very good!

Coke rate is: 344.41 kg / t HM. It is very good!

Coal rate is: 129.69 kg / t HM.

Fuel rate is: 474.1 kg / t HM. It is very good!

The blast temperature is: 1105 °C.

Fe content in ores is: 59.89%. It is very good!

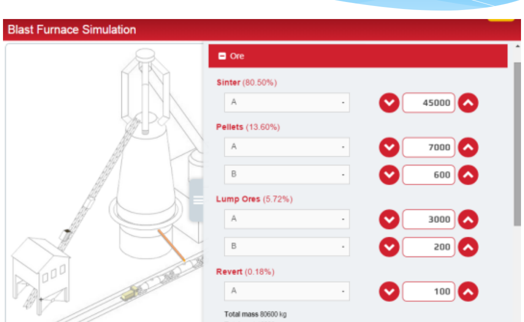
Energy utilization coefficient is: 92.07%. It is very good!

Carbon energy utilization coefficient is: 72.53%. It is very good!

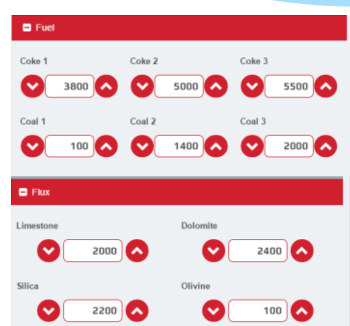
Mass balance error: 2.58%. This is higher than 2%.Please try to decrease it.

Total cost427.93 $ / t HM

ORE

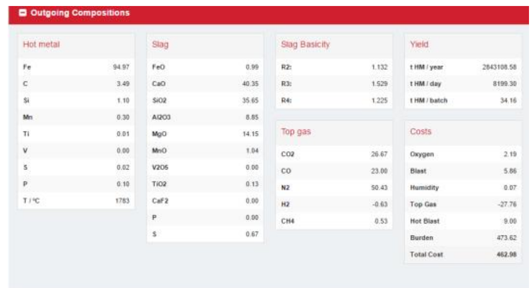


FUEL AND FLUX



OTHER PROPERTIES

OUTGOING COMPOSITION



Outgoing Compositions

Hot metal	
Fe	94.97
C	3.49
Si	1.10
Mn	0.30
Ti	0.01
V	0.00
S	0.02
P	0.10
T / °C	1783

Slag	
FeO	0.99
CaO	40.35
SiO2	35.65
Al2O3	8.85
MgO	14.15
MnO	1.04
V2O5	0.00
TiO2	0.13
CaF2	0.00
P	0.00
S	0.67

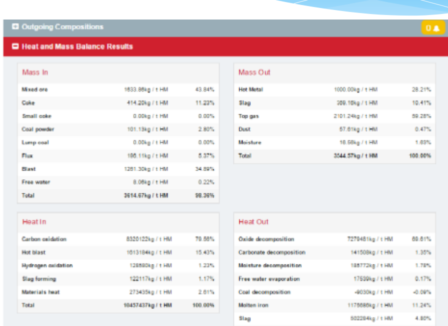
Slag Basicity	
R2:	1.132
R3:	1.529
R4:	1.225

Top gas	
CO2	26.67
CO	23.00
N2	50.43
H2	-0.63
CH4	0.53

Yield	
t HM / year	2843108.58
t HM / day	8199.30
t HM / batch	34.16

Costs	
Oxygen	2.19
Blast	5.86
Humidity	0.07
Top Gas	-27.76
Hot Blast	9.00
Burden	473.62
Total Cost	462.98

HEAT AND MASS BALANCE



Outgoing Compositions

Heat and Mass Balance Results

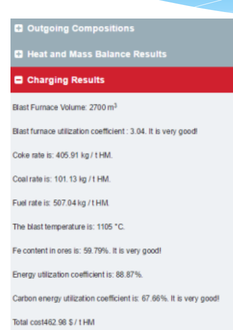
Mass In		
Mixed ore	1633.86kg / t HM	43.84%
Coke	414.20kg / t HM	11.23%
Small coke	0.00kg / t HM	0.00%
Coal powder	101.13kg / t HM	2.80%
Lump coal	0.00kg / t HM	0.00%
Flux	186.11kg / t HM	5.37%
Blast	1261.30kg / t HM	34.89%
Free water	8.06kg / t HM	0.22%
Total	3614.67kg / t HM	98.36%

Mass Out		
Hot Metal	1000.00kg / t HM	28.21%
Slag	369.16kg / t HM	10.41%
Top gas	2101.24kg / t HM	59.28%
Dust	57.61kg / t HM	0.47%
Moisture	16.56kg / t HM	1.63%
Total	3544.57kg / t HM	100.00%

Heat In		
Carbon oxidation	8320122kg / t HM	79.56%
Hot blast	1613184kg / t HM	15.43%
Hydrogen oxidation	128580kg / t HM	1.23%
Slag forming	122117kg / t HM	1.17%
Materials heat	273435kg / t HM	2.61%
Total	10457437kg / t HM	100.00%

Heat Out		
Oxide decomposition	7279481kg / t HM	69.61%
Carbonate decomposition	141508kg / t HM	1.35%
Moisture decomposition	185772kg / t HM	1.78%
Free water evaporation	17530kg / t HM	0.17%
Coal decomposition	-9030kg / t HM	-0.09%
Molten iron	1175686kg / t HM	11.24%
Slag	502284kg / t HM	4.80%
Top gas	523396kg / t HM	5.01%

CHARGING RESULTS



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