Cupola Efficiency Increase by Steam Injection.

Energy Reduction will reduce Liquid Metal Cost

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How to optimize Energy Efficiency of your Cupola by Steam Injection?

The melting rate of a cupola using low ash (14%) should be about 10 tonnes/hr/m^2 and for cupola using high ash coke (30%) should be about 7 tonnes/hr/m^2. The idea of Steam Injection in Cupola Furnace could be derived from the well stablished Blast Furnace Technology process. What could be achieved by incorporating this arrangement in Cupola Furnace will eventually decrease coke requirement. What happens when we inject steam through the tuyeres at close end of the furnace.

$C + H_2O \rightarrow CO + H_2$

Although the amount of Oxygen and Nitrogen will decrease slightly, the oxidizing power per unit volume of the blast increases since the H_2O has 89% of Oxygen. Bosh (Tuyere Area) gas volume will increase per unit volume of blast but it will decrease the amount of burnt carbon.

Injected Steam (g/Nm^3) of blast air through Tuyeres		0	10	20	40	60
Carbon burnt at the tuyeres % Nm^3 blast		-	1.72	3.44	6.9	10.3
Bosh gas volume % Nm^3 blast		-	0.81	1.62	3.25	4.87
Bosh gas volume %/ Kg C		-	0.85	1.75	3.4	4.92
Composition of Gas (Gas near Tuyeres)	CO %	-	34.7	35.04	35.34	36.52
	H %	-	1.02	2.02	3.98	5.88
	N_2 %	65.3	63.94	62.63	60.08	57.6
($CO + H_2$) %		-	4.68	9.38	18.72	28.1

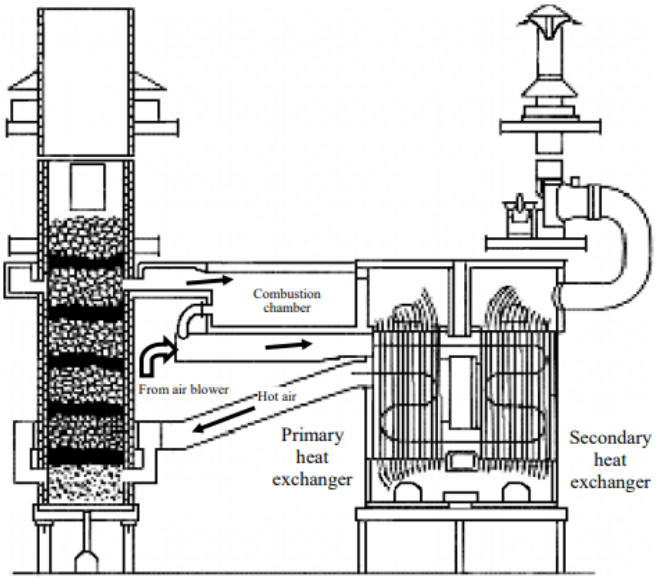

Fig. 1 Structure of a typical hot-blast cupola

The heat generated by burning carbon monoxide in the combustion chamber is utilized in the hot-blast recuperator to preheat combustion air to be returned into the cupola.

Increasing the oxygen concentration of blast reduces heat loss and the coke rate and increases thermal efficiency. The blast rate and pressure have an important influence on cupola performance. Optimum blast rate would be 115 m^3 /min per square metre. • Blower rating should be 15%-20% more than the optimum blast rate, to account for air losses in the pipeline.

Benefits of Steam Injection at the Tuyere Point.

Steam can be used profitably to increase the production rate for the following reasons.

1. Higher gasifying power intensifying coke consumption in the race way.

2. Smoothens the temperature gradient and facilitates stock decent.
3. Enlarges the combustion zone and accelerates stock descent, heats up the axial zone and maintains thermal state of the hearth.
4. Higher reducing power and high heat transfer coefficient of H_2 compensates incomplete temperature inside the furnace. Hence able to accommodate more rusted inputs.
5. Decreases pressure loss due to lower density and viscosity of H_2. The blast pressure may drop even by 0.1-0.2 atmosphere which allows the furnace to be blown at higher blast rate.

By compensating the flame temperature, the increase in production can be approximately calculated from the decrease in tuyer gas volume per unit of blast volume, because of availability of H_2 & O_2 from Steam. 20 grams of steam per Nm^3 of blast air at 1100 °C can result in 5-6% increase in production as compared to blast temperature of 900 °C with no moisture.

Effect of H_2

H_2 is a more potent reducing agent and results in smoother and faster furnace movement because of enlargement of combustion zone and results in more hearth area thereby raising the slag fusion zone upwards. A larger heat input and better indirect reduction through H_2 which results in saving of coke.

$FeO + 3.3\ CO \rightarrow Fe + 2.3\ CO + CO_2$; η CO FeO = 30%

$FeO + 2.7\ H2 \rightarrow Fe + 1.7\ H_2 + H_2O$; η H FeO = 37%

1 Kg of H_2 will remove same amount of wustite oxygen as will be done by CO evolved from 7.2 Kg Carbon.

Further, if hydrogen pressure increases to 0.5 Kg/cm^2, a very high temperature is produced inside the furnace. The basic theory behind this process is that a molecule of hydrogen consists of two atoms of hydrogen. The atom of hydrogen is not stable and possesses a strong tendency to combine to form the molecular hydrogen. When two atoms of hydrogen combine they produce intense heat. This heat could be used to reduce the Iron ore in the Blast furnace.

$H + H \rightarrow H2 + 100.7$ kCal

Steam is Expensive, where to get it from?

A solar steam system comprising of 96 sq.m of dish area of this technology (6 dishes each of 16 sq. m) may generate around 150 to 200 kg of steam in a day depending on location. The steam could be generated and delivered at 300 °C upto 20 bar.

The concentrator tracks the sun on two axes, continuously facing it to capture maximum amount of solar radiation over a day. The dish concentrator along with the receiver is mounted on a specially designed tower. The system is equipped with a heat retrieval mechanism (which may consist of piping and fittings, insulation, fluid circulating pump, etc.), and system controls related to tracking, thermal system and security/ emergency measures.

Other than usage of steam in the injector, one can use the same steam with cast-iron heat-radiators.

We could also use the cooling water from the Induction Furnace to generate steam.

The best source of steam for Hot-Blast Cupola could be from its own the Heat-Exchanger.

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