**COKELESS CUPOLA**

**A Cost Effective and Environment Friendly Melting Furnace**

**Introduction**

The original cokeless cupola was invented by Mr. Richard Thomas Taft, Managing Director of Cokeless Cupolas Ltd, UK and was patented in 1972.

The development of the cokeless cupola began in the United Kingdom at the foundry of Hayes Shell Cast Limited in the mid 1960s. A pilot furnace was built during 1967 to prove the ideas of melting Cast Iron with gas at a relatively low temperature and then superheating by some other means. From the trials that took place it was established that iron of suitable temperature and composition could be tapped directly from the furnace without any superheating. As a result of this success one of the existing 5 tonnes per hour cupolas was converted to the cokeless system in November 1970.

**Features**

In a conventional coke fired cupola the coke has three functions.

1. It acts as a source of heat
2. In the bed it superheats the iron as it trickles over the coke
3. It acts as a source of carbon.

In the cokeless cupola these functions are provided by three different means.

*Schematic representation of Cokeless Cupola*
1. Heat is provided by the burners, which can be fired with a variety of fuels such as natural gas, diesel oil, propane or other suitable fuels.

![Wesman high velocity short flame Burner](image)

2. Superheating is done by the specially developed spheres that form the refractory bed. The Spheres are supported by a water-cooled grate consisting of specially designed mild steel tubes, which may be coated with refractory. This bed is similar in its function to the bed in a coke cupola, and the metal is superheated as it trickles over the spheres.

![Refractory spheres](image)

![Refractory spheres in hot bed](image)
3. As there is no carbon pickup in the Cokeless Cupola, this is added either by continual injection into the well of the cupola or outside in an electric furnace.

The cupola is operated with partially reducing conditions. It is very important that the correct air/fuel ratio is maintained at all times. Otherwise the required temperature will not be achieved as the furnace temperature reduces steeply with both excess fuel and excess air condition. An automatic control system forms part of the main control panel and the air and fuel flows to each burner are also monitored.

**Unit melting**
The Cokeless Cupola technology can be applied in the traditional manner as a unit melter when high temperature metal of the right composition is available directly from the cupola into ladles for pouring into moulds.

This type of operation has been applied in many foundries in different countries but it is generally limited to smaller and medium size foundries operating up to 4/5 tonnes per hour and melting for up to 8 hours per day. In a unit melter fairly high tapping temperatures will be required. To achieve tapping temperatures of around 1450 to 1460 deg C a bed height of around 650 mm would be required. This means higher rate of consumption of spheres. However if lower temperatures are sufficient then the bed height can be reduced which will reduce the sphere consumption.

Since the spheres will not provide the necessary carbon, and since in Cokeless Cupola there is approximately a 10% carbon loss during melting, with the usual charge make up, it will be necessary to add some carbon to the iron. A carbon injection unit, therefore, will be required which continually blows carbon into the cupola during melting. The rate of injection can be controlled.
Duplexing
A cupola is a very efficient melting unit as cold material is added to the top; the metal is preheated as it moves down the shaft and after melting is superheated as it passes through the bed. If high temperature metal is required from a coke cupola the coke consumption is increased considerably. In the case of the Cokeless this also increases the consumption of the bed material, hence super heating is less economical in both cases.

An electric furnace is not a very efficient melting unit but once the metal is liquid the superheating of the iron is very efficient. Therefore melting iron in cupola at low temperature and superheating in an electric furnace is a very cost effective combination. This is called duplexing.

In case of duplexing a low bed of around 250 mm is used corresponding to only two rows of spheres which when new are approximately 150 mm in diameter. This drastically reduces the consumption of bed material – spheres. Reduced bed height reduces the tapping temperature but increases the melting rate. Therefore, compared with a unit melter, the overall gas consumption also reduces.

Advantages:

a) Coke not required:
India does not have reserve of good quality coking coal. We have to import coke from other countries. Use of Cokeless Cupola will eliminate the use of coke.

Gas is being becoming available at various locations through out the country. To take advantage of the availability of natural gas in many parts of the country, Cokeless Cupolas should be used extensively. The Cokeless Cupola can also be fired with LPG, or Light Diesel Oil.

b) No / Low Pollution
The Cokeless Cupola was developed over 30 years ago and a comment passed about its performance in the early days is still very appropriate and probably more relevant, particularly in view of today’s stringent pollution norms. The comment was “What does not come out the top is more important than the metal from the bottom”.

Cupola top showing no emission during melting
There is an increasing worldwide awareness of the impact that many processes can have on the environment. This is certainly true for foundries in India where the cost of meeting new regulations is significant.

Undoubtedly, a conventional coke cupola does cause a lot of pollution. Besides suspended particulate matter, there are also carbon monoxide, carbon dioxide and sulphur emissions, all of which are not good for the environment. If the cupola was converted to cokeless operation there would be no visible emission, there would be no sulphur emissions and the amount of carbon emissions are approximately 1/6 that of coke operation. There is less than 2% carbon monoxide in the waste gas. There will still be some dust emissions contained in the charge but these can be readily removed if required. Depending on the regulations, there can be a considerable saving in capital cost as well as savings in running cost. In short there is dramatic reduction in pollution level with the SPM level being well within the Indian pollution limit of 150mg/CuM.

c) Saving in Raw material
Pig iron is the most expensive raw material in the charge for cupola where as steel scrap is cheaper. Foundries with coke cupola may be limited on the amount of steel scrap they can use particularly if they are trying to obtain relatively high carbons. However, with the injection process used in the Cokeless Cupola, this does not present a problem. Up to 30% steel scrap can be used in the charge. Similar percentage of SPONGE IRON may also be used in Cokeless Cupola melting, provided suitable arrangements to charge it are made.

d) Other Advantages
Once a cupola has been converted to cokeless operation, the foundry would be in a position to produce ductile iron and some graded iron without the need for an electric furnace. As this is a considerable growth area in India, it would offer the foundry an additional advantage over its competitors who were still using a conventional coke cupola.

In case of Cokeless cupola, the attack on lining is less and the life of lining is more. This makes maintenance easier and more economic. Longer melt campaign upto 48 hours is possible with some modifications in the refractory specification and water spray cooling of the shell near the burner area.

The foundry industry in India is rapidly expanding and many foundries have adopted electric melting, particularly for the production of ductile iron. For these foundries where expansion is being considered, the capital investment of installing a Cokeless Cupola could well be considerably less than adding additional electric furnaces. Liquid metal could be transferred from the Cokeless Cupola to the existing electric furnaces where they would be used for superheating and recarburising the metal instead of purely melting. The existing electric capacity would be more than sufficient for any expansion as less than 100 kW hrs per tonne are required for superheating and recarburising whereas generally more than 600 kW hrs per tonne are required for electric melting.
e) It also reduces Melting Cost
Tapping temperature has the main influence on economics, which as described above depends mainly on bed height. This influences the melting rate, which also effects the gas consumption.

With the unit melter operating at 1450 deg C, natural gas would be consumed at around 85 cu m per tonne with a typical sphere consumption of around 2.5 %. In the duplex operation gas consumption can be down to 55 cu m per tonne with sphere consumption as low as 1 %.

In both cases the amount of recarburiser will depend on the charge make up and the final analysis required. In the duplex operation the recarburiser will be added in the electric furnace with a recovery approaching 100 %. Whereas with the unit melter the recovery is only around 50 %. The cost will vary depending on the type of metal being produced and whether graphite or a cheaper recarburiser is used in the process.

No two foundries are alike and there will be variations in charge make up, tapping temperature, final analysis required and the method of manufacture can also influence metal requirements. It may noted that the duplex operation gives highest saving. Although the price of coke, fuel and electric rates may vary from location to location, it is clear that the cokeless system can offer considerable economic benefits.

The Original Taft Cokeless Cupula Comes to India
Since the invention of cokeless cupula, many have been installed in various countries all over the world including UK, Germany, Japan, Korea, UAE, Iran, and Chile.

It will be of interest to Indian foundrymen to know that the eco-friendly cokeless cupula technology is now available indigenously in India. To make this possible a technical collaboration agreement has been signed on December 9, 2005 in Kolkata between Wesman Engineering and Cokeless Cupolas Ltd to offer this technology to Indian users. The agreement specifically covers the exclusive manufacture of the refractory spheres in India. Initially, the spheres are manufactured in Kolkata, but depending on the demand, refractory spheres could also be made in locations where there are clusters of foundries.

Under the agreement, it is envisaged that the individual foundry will obtain a license from Cokeless Cupolas Ltd. The license fee will be dependant on the melt rate of the cupola @ GBP 2000 per tonne of cupola capacity. Thus it will be GBP 6000 for a 3TPH cokeless cupula and GBP 10000 for a 5 TPH cupula. Mr. Taft will provide his support either by mail of on telephone. His personal visits can also be arranged at extra cost if there are number of installations in nearby locations. Wesman will supply the complete combustion and control package and some essential accessories. The foundry will manufacture a new cokeless cupula or modify an existing coke fired cupula based on drawings provided by Wesman. To reduce the costs to the minimum, the foundry can also provide itself all the air, gas/oil pipelines including all electrical installation.
Manufacturing of Spheres in India
As a consequence of the above agreement, most of the raw materials have been identified indigenously, tested and approved by Mr. Taft. Some quantity of certain additive, specially formulated for the production of refractory spheres and used in the original spheres made in the UK, is being imported from UK.

Manufacturing set up including facilities for testing the raw material as well as the finished spheres have been installed at Wesman’s works. The production has started in the month of September 2006 in the presence of Mr. Taft.

Mr. Taft took with him some “made in India” spheres to the UK and had them tested in the same laboratory where the original spheres made in UK were tested. The “made in India” spheres were found to be equally good.

With the actions taken as above, the ferrous foundries in India will now have the option to adopt the original world-class eco-friendly Wesman-Taft Cokeless Cupola technology. An important consumable like the refractory sphere, which is the key element in the whole process is now produced and available indigenously. It is for us now to take advantage of availability of the most suited technology to become more competitive in the domestic as well as in the international market.