# Late 19th and Early 20th Century Steel Making in Germany using the Open Hearth Process

**Photographs of Models Displayed in the Deutsche Technical Museum in Munich**

## Introduction

The Open Hearth furnace was invented in Germany by Carl Wilhelm Siemens, who had the aim of developing a furnace capable of reaching higher temperatures than any other coal fired design. He did this by preheating the combustion air and producer gas-type fuel, using the waste heat in the combustion products from the furnace. In my experience, temperatures approaching 1600°C are possible.

Siemen's design, developed in the 1850s, was not specifically intended for steel manufacture, but in 1865, the Frenchman Pierre Émile Martin began to use it for steel making, where it eventually swept the field. The obvious advantage it had over the Bessemer process is that it could be used for melting scrap metal, which was becoming widely available by the middle of the 19th Century. Also, because it took several hours to produce steel using the open hearth, it was far easier to make steel of a specific composition.

In the original process, bulks of pig iron, along with steel scrap, mill scale (oxidised iron, mainly FeO, produced when rolling steel), and lime (calcined limestone, CaO) were loaded into the open hearth "bath". The pig iron quickly melted down, with the carbon and silicon then reacting with the mill scale. The reaction of carbon in the molten pig iron would form carbon monoxide, the bubbles of which put the molten bath into a highly turbulent condition. This was essential to stir in the lime, enabling it to do its refining action. However, molten slag and iron could splash out of the bath. Could be dangerous!

Furthermore, in the refining action, the silicon would first oxidise to form silica, only then reacting with the lime to form a molten slag. The slag also absorbed any phosphorous that was in the pig iron. Some of the slag was periodically tapped off, and extra limestone was added from time to time.

Once the molten steel had been brought to a satisfactory state, the slag was poured off and the steel tapped into a large ladle. Chunks of ferro silicon alloy would be added to deoxidise the melt. The molten steel was then tapped off into individual ingots. (See Later).

## Furnace Views

**Here I am having to do some guesswork as Figures 1, 2 and 3 are all from the same display casing, and I think they are an effort to show the progress over about 30 to 50 years, since the open hearth was first introduced in the 1860s.**

Figure 1 appears to show one of the earlier models, in which all the charging of pig iron, scrap and lime is done by hand. The bloke peeping into the furnace, is, apparently, judging the state of the melt, and may have been the main man in charge.

In England he was referred to as the sample passer. Because of the intense radiation, the door of the furnace is opened as little as possible, and as you see, the man stands well back!

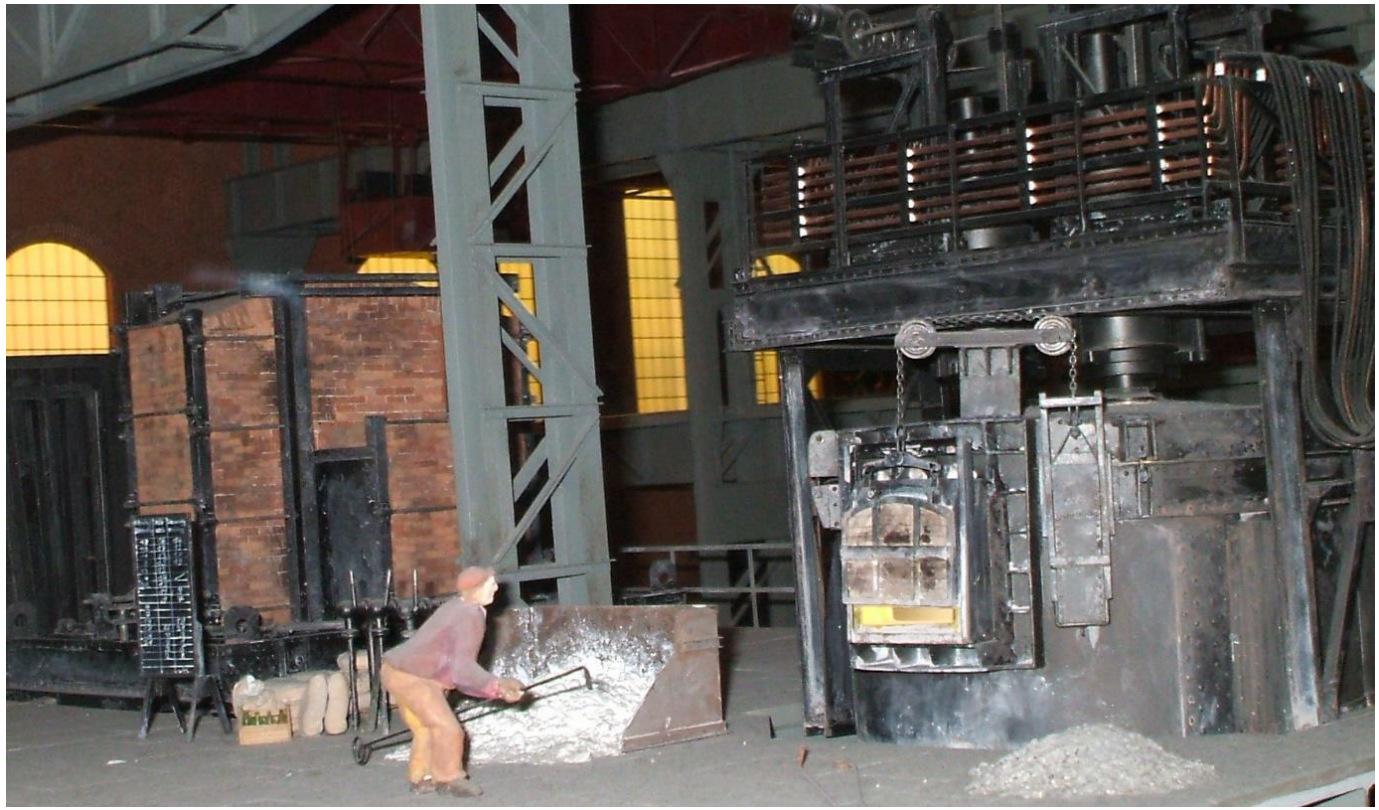

**Figure 1**

Figure 2 shows a bigger and later design of open hearth, with three doors for charging pig iron etc. However, judging from its relatively short length, it is one still using firing with producer gas (essentially a mixture of carbon monoxide and nitrogen). This, plus the combustion air, enters through burner and air inlet ports arranged across the breadth of the furnace.

It seems likely that the man pushing the rod into the furnace is attempting to get a sample of the steel. When poured into a simple mould, and broken with a hammer, the appearance of the fracture and ductility of the sample would be a guide to the carbon content.

**Figure 2**


**Fig 3**

Figure 3 is a view of most of the display case. Note the crane-like arrangement with the long horizontal arm and steel basket. It is used for loading pig iron, scrap and lime into the furnace. It is suspended from a gantry that runs parallel to the furnace

Figure 4 shows an overall view of the back of the later model open hearth furnace. It is here where the molten steel and slag are tapped off. The furnace itself is about ten metres above ground level and is hidden behind the extremely deep girder. However, the railings around the walkway at the back of the furnace can be seen.

A small ladle, used when slag is being tapped, can be seen in the middle distance, but the main action is in the foreground where molten steel is being poured into ingot moulds


**Fig 4**

Figure 5 is a close up of the above, concentrating on the tapping of the steel ladle. The man wearing a leather apron is holding a lever, which controls the flow of molten steel out of the ladle into each “ingot mold”. An attempt has been made to show which moulds have been filled. The filled molds will be taken to another building where the ingots are “stripped out”.

A rather ingenious plug valve made of temperature resistant refractory holds back the steel. The flow is shut off as the ladle moves from a full ingot to an empty one. However, the plug valve can wear and fail to hold back the flow. When this happens droplets of molten steel splash all over the place. It is like dropping mercury onto the floor.

The man in brown trousers, who is looking into a ladle, is renewing the plug.

**Fig 5**

Figure 6 is in another part of the steelworks in which scrap steel is being loaded from railway waggons into baskets. These will be used by the open hearth furnace loader, as shown in Figure 3

**Figure 6**