



## Effective production of zinc oxide through the indirect process

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### Abstract

Zinc oxide an inorganic compound shows a wide range of industrial applications and due to wide range of application its demand is increasing day by day. To tackle these demands we have to make some changes into standard process. Today more than half of zinc oxide is produced through indirect process, this requires heavy investment. So, as per the investment we have to take maximum output from this process. this process was invented in 1844 in French during the period of industrialization. To tackle modern day problems we have to make some changes in standard process. This newly developed method has increased the production by using fewer resources.

**Keywords:** ZnO, zinc oxide, indirect process, reaction time

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### Introduction

Zinc oxide is an inorganic compound with the formula ZnO. Due to its multiple chemical and physical characterizations, it has a wide application in various industries like the ceramic industry<sup>[1]</sup>, paint industry<sup>[2]</sup> and rubber vulcanization industry<sup>[3-6]</sup>.

In the industrial world, zinc oxide is made using the "indirect method," also known as the "French process," and the "direct process," also known as the "American process". But, about 68-70% of zinc oxide is produced through an indirect process.<sup>[7]</sup> The indirect process is more efficient than any other process which is used to produce zinc oxide.

The quality of produced zinc oxide depends on two factors first is the quality of raw material and the second is the atmospheric condition around the furnace. The main purpose to conduct this experiment is to get more outcomes in minimum resources.

### Materials and methods

To conduct this experiment, we have to use the indirect method in which zinc is vaporized and get oxidized by the atmospheric oxygen. We have to use some instruments for production purposes like an oil-furnace, classifier, bag filter, and blender. Secondary zinc such as scrape and galvanize dross<sup>[8]</sup> is used as raw material. By indirect process, we have to go through two steps first one is purification or ingot formation and secondary oxidation.

### Experimental

In industry, the mostly indirect technique is utilised to produce zinc oxide. This method is called the indirect process because raw materials are not used for production but instead of those firstly raw materials are passed through the purification stage to remove impurities like Pb, Mn, and Fe then raw materials is consumed for production purposes therefore this process is called indirect process.<sup>[5]</sup>

Before looking into the new process, understanding the classical process will give a clear idea of the new process.

#### 1. Classical method

For indirect process, raw materials are secondary zinc such as scrape and galvanize dross.<sup>[8]</sup> These raw materials contain impurities such as lead, manganese, and ferrous. To deduct these impurities raw materials are gone through the purification method.

For purification raw materials are sent to a graphite crucible and increased the temperature up to 900°C which is the melting point of pure zinc, at this stage some lightweight impurities come on the surface, and heavy impurities such as sand sink down to the crucible. Dressing flux is used to remove impurities as slag. Slag is removed with the help of tongs. And bottom impurities are removed by the tipping method.

Then molten zinc is transferred to ingots molds. This is how ingots are formed and these ingots are used in the second step. In the second step purified zinc ingots are converted to zinc oxide that many instruments are used such as a burner, furnace, fume hood, ducting pipes, classifier, bag filter, and blender.

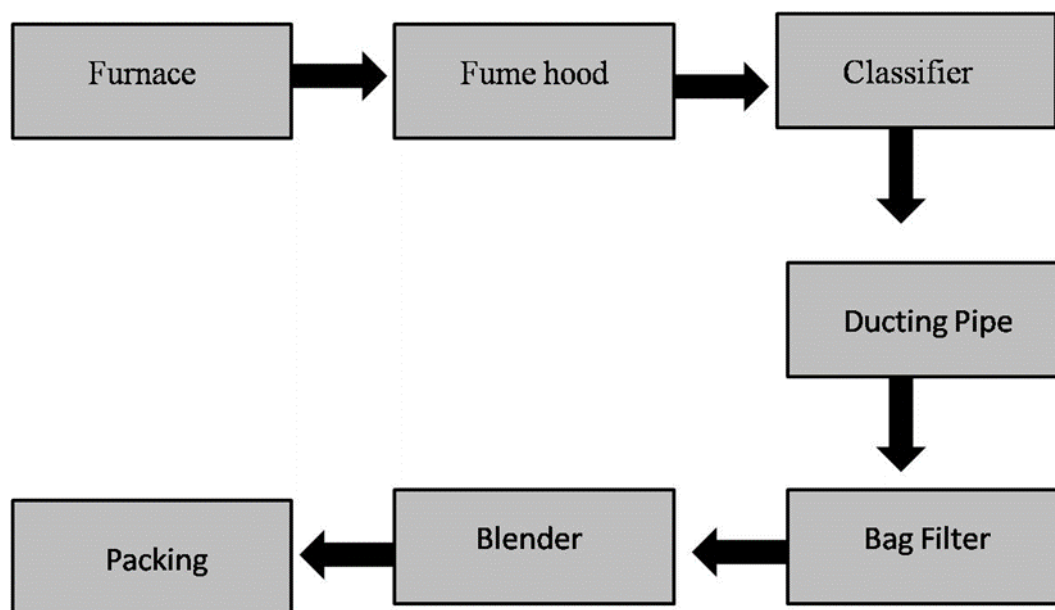
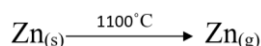
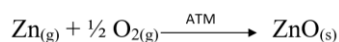


Fig 1: Flow diagram

In this second stage, 650Kg solid zinc metal is fed into the furnace. The recharge time of the furnace is 5 hours. That indicates the next batch of 650Kg will be supplied in 5 hours. Now, this batch is heated up to 1100°C. At this temperature, molten zinc starts evaporating which is shown in the following equation.



When evaporated zinc comes into contact with air oxygen after evaporation, it oxidizes. And after oxidation, this vapor of zinc is converted into solid white particles of zinc oxide. This is shown in the following reaction



This is collected by fume hood. Collected zinc oxide powder then reaches the classifier. The classifier works on the principle of density difference. The classifier removes any heavy impurities and non-reacted zinc metal which is again used for purification.

This lightweight powder is still hot so this powder is passed through the ducting pipe. Ducting pipe is 50 meters to 300 meters long metallic pipe. This helps to cool the zinc oxide powder then this powder is collected by a bag filter with a cloth bag. Zinc oxide collected by bag filter is sent to blender. Blender is used to densify the zinc oxide powder. Then after the powder is sent for packing operations

Classical methods have some drawbacks like cycle time of this process is 5 hours. During this time employees are free they have nothing to do and after 5 hour, when the furnace is to be recharged, the output of the furnace is stopped but, the furnace do not get cold so the burner has to be continued and due to this more oil is used therefore the introduction of new method is required.

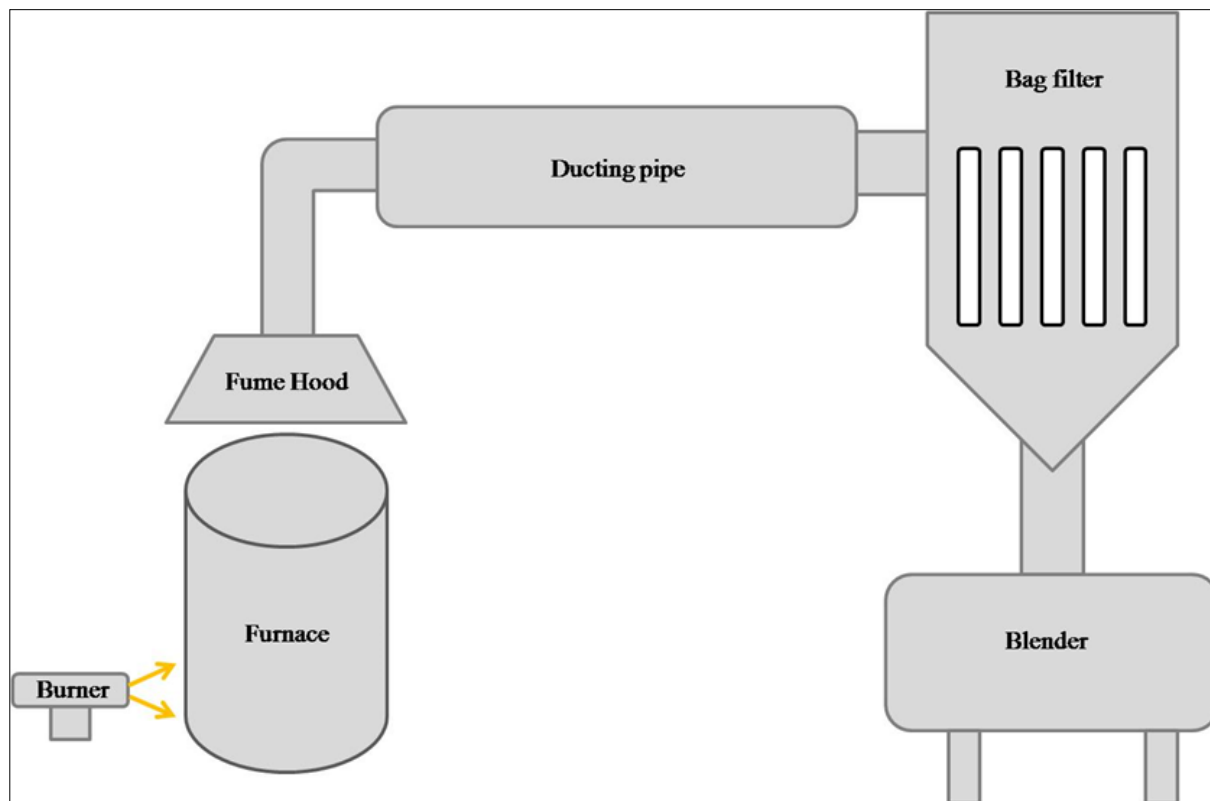
## 2. Morden Method

To eliminate drawbacks of the classical method this method is developed. Before doing any changes to the classical method, the current charging rate of the classical method is to be known. For that, carry out one survey which includes the weight of charged materials and the time of recharging. After the calculation of the collected data, it shows that the current charging rate is 130 Kg/hr. That means in 1 hour 130 Kg of raw material is being used. The main aim of this method is to reduce the shut-down time of the furnace.

First of all, for purification of raw materials all raw materials are transferred to the granite crucible. The temperature of the crucible is up to 900°C at this temperature lightweight impurities come on the surface and heavy impurities descend to the crucible. Drossing flux is used to remove impurities by slag formation. Then slag is removed with help of tongs and impurities from the base are removed by the tipping method.

Then molten zinc is transferred to ingot molds this is how ingots are formed, which will be used in the second part. But here is some change. In this method, comparatively thin ingots are formed compared to classical

method. Before understanding the second part of this method, let's have a look into the instrument setup to get a clearer idea of the process.



**Fig 2:** Instrumental set-up

In the second stage when the first time furnace starts, feed 650 Kg and after every 1 hour, recharge the batch of 130 Kg. Now recharge time of the furnace become 1 hour which means after an hour furnace has been recharged with 130 Kg ingots. And to avoid interruption of output slightly up the lid and push the raw material inside the furnace this is how without interruption production will be continued and if there is no interruption in output heat of the burner is correctly utilized that's how consumption of oil is also decreased.

After feeding the raw materials the temperature of the furnace increased up to 1100°C at this temperature solid zinc metal is converted to liquid zinc and this liquid zinc is converted to the gaseous phase. This gaseous phase of zinc came out through the lid of the furnace.

When the vaporized zinc came into contact with atmospheric oxygen it becomes zinc oxide. After oxidation gaseous zinc is converted into white solid powdered zinc oxide. The powder is collected by a fume hood. Through fume hood powder reaches up to classifier, classifier works on the principle of density difference. The classifier removes any heavy impurities such as atmospheric dust and non-reacted zinc meal which is sent to purification and again used for production purposes.

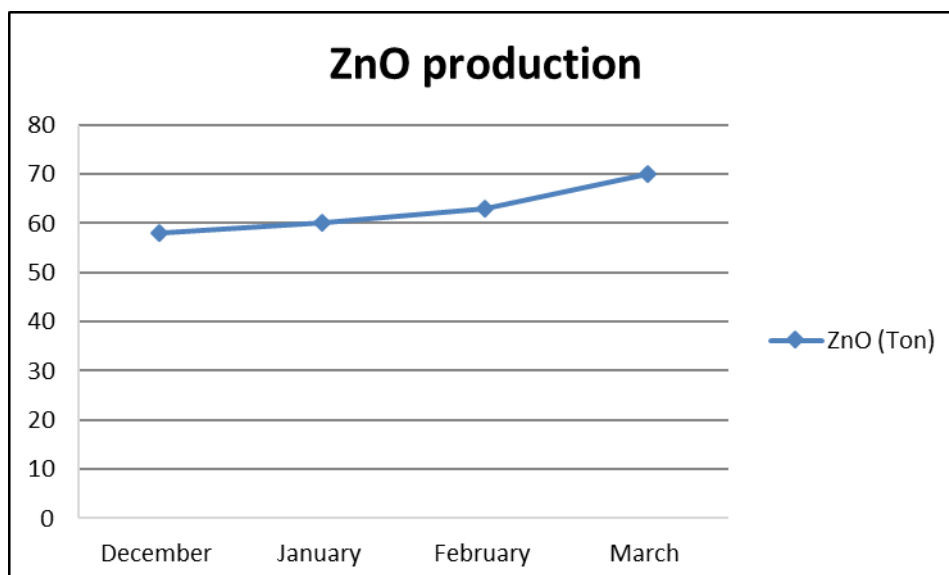
Still, the zinc oxide powder is hot. So, to decrease the temperature of zinc oxide powder, the powder is sent to ducting pipe, ducting pipe is 50meter to 300meter metallic pipe which is used to reduce the temperature of the zinc oxide powder. Then the powder is sent to the bag filter. The bag filter contains a clothing bag that is used to trap powder. With the help of compressed air pulsation, all powder falls into the blender. Blender densifies the powder and increases its weight of powder and then the powder is sent for the packaging process.

This method has some benefits over the classical method such as in this method all workforce is engaged during the process and in same resources, more production is gained as well as in this method fuel consumption is a comparatively less than the classical method.

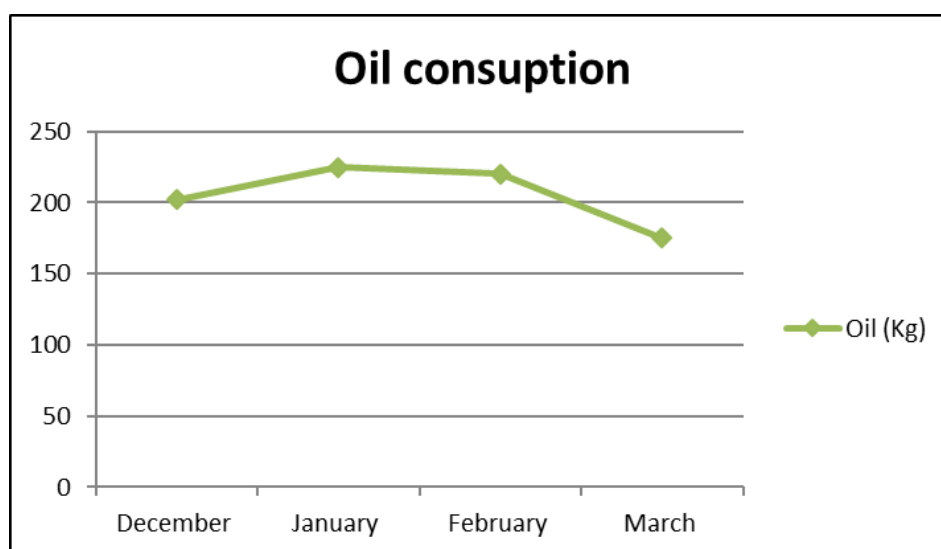
Some factors may affect the quality and quantity of zinc oxide powder; these factors are here, moisture content of the atmosphere around the furnace, the quantity, and availability of oxygen in the atmosphere, and most importantly temperature of the furnace, and diameter of the furnace.

### Result

After all observations it is concluded that with the Morden method production is increase up to 28% and consumption of furnace oil is decreased up to 12%, this benefit can be seen here in form of a graphical phase.



**Fig 3:** Production of Zinc Oxide



**Fig 4:** Consumption of Oil

If both methods are compared then a clearer picture of the benefits and drawbacks of the classical and modern methods are achieved.

**Table 1:** Comparative Study

Old method	New method
Charging rate: - 650kg per 5 hours	Charging rate: - 130kg per 1 hour
Oil consumption is high	Oil consumption is low
Workers have free time to relax	Workers are engaged in the process
Production is low by using more resources	Production is high by using fewer resources

### Conclusion

After all calculations and comparisons, it is concluded that Morden method is more efficient than the classical method because at the same time modern method gives more output than the classical method, also it decreases the consumption of oil. It directly affects the cost of production and profit.

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