

## Soba Upper- Draught Hoff-Mann Kiln Temperature Distribution

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**Abstract-** This study aimed to convert the operation of Soba circular kiln, the top-fired one, with the suction of hot gases up-wards (upper- draught kiln), to the way of suction of heat down-wards (down-draught kiln) in order to draw and distribute the high concentrated quantity of heat at the kiln top-crown down-wards to the bottom of the kiln, and allover of it as much as possible. Suction-pipes of special specifications was used to link between the bottom of the kiln and the main exhaust suction-pipes system in order to draw the hot gases concentrated at the kiln top-crown, down-wards to the bottom of the kiln. Extensive field work and laboratory studies had been carried out during this study achieved a consistent results and finding lead to a good high quantity and quality of fired red bricks.

**Keywords:** Kiln firing- process, Heat suction- pipes, down-draught, Heat balance.

### مستخلص:

هدفت هذه الدراسة لتغيير عمل الفرن الدائري الموجود حالياً بسوبا ذو ولعة الحريق العلوية، والذي يعمل بطريقة سحب الهواء الساخن لأعلى (ذو السحب لأعلى) إلى طريقة السحب لأسفل الفرن (ذو السحب لأسفل)، ذلك بغرض سحب كميات الحرارة العالية المتمركزة أعلى الفرن لأسفله وتوزيعها داخل الفرن توزيعاً متساوياً ومتوازناً لأكبر قدر ممكن. تمت عملية التعديل هذه بتصميم مواسير ساحبة بمواصفات هندسية خاصة استخدمت أثناء فترة تشغيل الفرن بعد أن تم توصيلها ما بين أسفل الفرن والخط الرئيسي الساحب للعوادم بالفرن حتى تتم عملية السحب المطلوبة من أعلى الفرن لأسفله. أجريت عدة تجارب ميدانية ومعملية أثناء هذا التعديل أدت إلى نتائج هامة تمت الاستفادة منها في رفع جودة المنتج من الطوب الأحمر المحروق كماً وكيفاً.

### Introduction

A kiln is a thermally insulated oven in which a controlled temperature regime is produced in order to fire the bricks to a pre-determined hardness. Hoff-Mann kiln, or a moving-fire kiln is the most convenient type of kiln originally associated with the name of Hoff-Mann kiln related to Fredrick Hoff-Mann in Germany about 185<sup>(1)</sup>. It can be divided into two types:

#### Upper-Draught Kiln

It is a top-fired kiln. Air batteries used for firing the bricks are situated at the kiln top-crown. Suction of heat and draught are directed up-wards<sup>(2)</sup>. That is why heat is concentrated more on the kiln top-crown Figure 1.

#### Down-Draught Kiln

It is a top-fired kiln. Air batteries used for firing are situated at the kiln top-crown. Suction of heat and the draught are directed down-wards to the bottom of the kiln through underneath constructed exhaust channels<sup>(3)</sup>. For these reasons heat concentrated at the kiln top-crown had been drawn and distributed down-wards. Therefore down-draught kiln is convenient and more efficient than the upper-draught one.

The existing Soba Hoff-Mann kiln is a top-fired one with an upper-draught. For these reasons heat is concentrated at the kiln top-crown more than that at the bottom<sup>(4)</sup>. Many problems associated with this type of kilns had been appeared. These problems can be summarized as follows

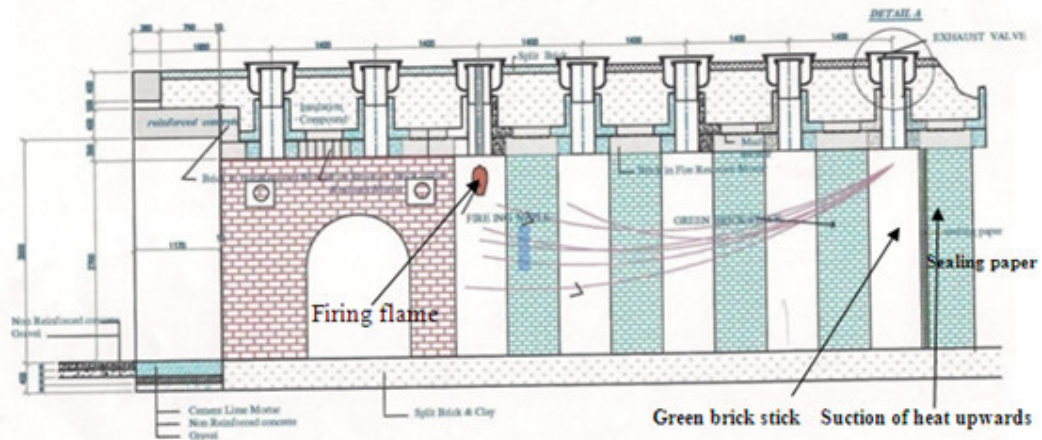


Figure 1 Upper-draught kiln<sup>(6)</sup>

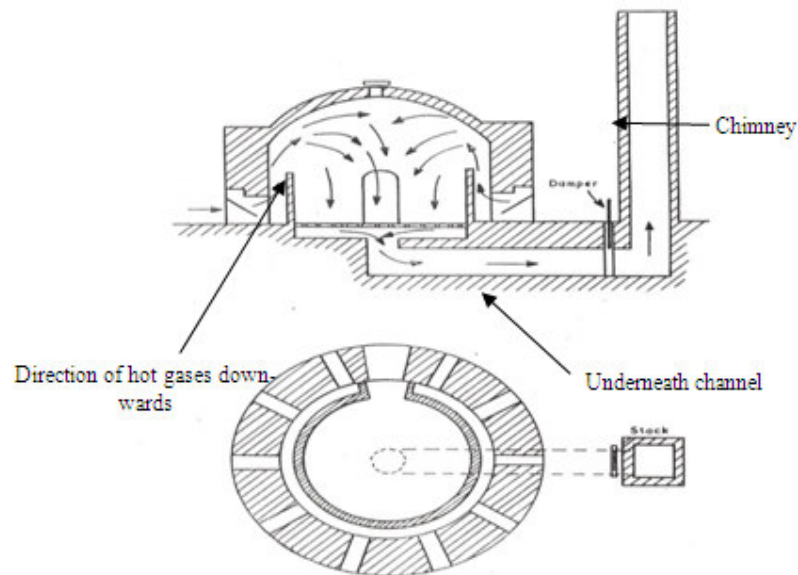


Figure 2 Down-draught kiln<sup>(8)</sup>

- a. Over fired bricks at the top of the stacked bricks.
- b. Under fired bricks at the bottom of the stacked bricks.
- c. Bricks cracks and damage.
- d. Brick color variations.
- e. Temperature variations.

The objectives of the proposed method are

- a. To maintain even heat distribution inside the kiln.
- b. To improve the quality of the products, and to reduce losses.

**Experimental Design**

Two options for the modification and improvements of Soba upper-draught kiln were applied in this paper

**Option one**

Making an underneath exhaust-channels within the kiln building structure As mentioned before the existing kiln of Soba brick plant is an upper-draught kiln. For this reason heat is concentrated mainly at the kiln top-crown. To solve this problem, firstly it was suggested to construct an underneath exhaust fume channels (within the kiln building structure) to direct heat-flow down-wards by means of an exhaust-

fan (forced draught). This new suggested system will convert this upper-draught kiln to function as an efficient down-draught one (with better heat distribution). The disadvantages of this option can be summarized as

a. It may lead to kiln's building structural failure.

b. High modification cost. (Due to civil work).

**Option two**

This option can be applied by using suitable designed suction-pipes having specifications shown in Table 1.

Table 1 suction-pipes parameters

Item	Value
Suction - pipe diameter (mm)	100
Pipe length (mm)	2700
Material	High temp. resistance steel

A proper exhaust-valve sealing cover was fixed between the exhaust-valve and the suction-pipe upper-end for air tightness<sup>(5)</sup>. The suction-pipes were inserted inside the kiln, linking between the kiln bottom and the main exhaust-system through the exhaust-valve, and then connected to the chimney with an exhaust-fan used for the forced draught, as shown in Figures 3 and 4. The function of these suction-pipes was to draw the hot gases concentrated at the kiln top-crown (The higher temperature region) down-wards to the bottom of the kiln (Lower temperature region).

These suction-pipes should be inserted during the kiln firing-process, at the preheating-zone region, when the temperature is about 150 C° – 200 C° or after brick water smoking period<sup>(6)</sup>. This precaution is very important. It will stop and prevent water-condensation and contamination on the top exhaust-valve.

**Experimental work & materials**

The experimental work was carried out during the kiln firing-process, using the heat resistance suction-pipes. Different temperature measuring devices were used during the kiln firing-process, such as thermostats, thermocouples, seger-cones, etc.

Thermostats were used for recording the temperature readings during the kiln different firing-zones, such as preheating-zone, full-firing zone, and cooling-zone. Thermocouples also were used to indicate and controlling the brick finishing temperature (at about 900<sup>0</sup>C).

**Seger Cones**

Seger cones are a pyrometric devices used to gauge the temperature rise inside the kiln at any position during the kiln firing-process. They have different code numbers. Each code number indicates a certain melting temperature. Usually they are used in three sets<sup>(7)</sup>. Each set has three different ranges of temperature. The first one was chosen to carry an equivalent temperature above the expected temperature. The second one for the desired temperature and the third one was chosen to be less than the expected temperature<sup>(8)</sup>.

Plate 1 showed the three sets of seger cones groups. They were prepared and fixed upright on a fired- brick stand. Each set contained equivalent temperature of 950°C, 830°C, and 700°C. These three similar sets should be inserted between green bricks stack before kiln firing- process.

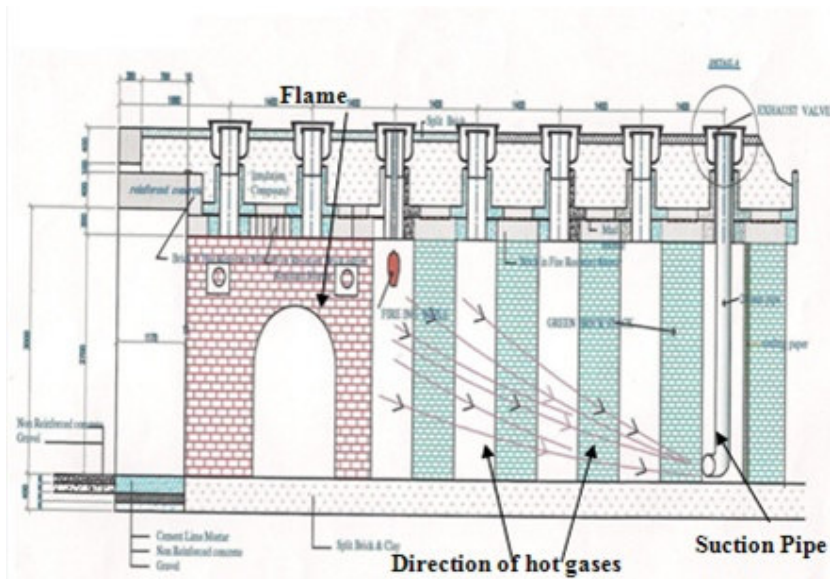


Figure 3 Down-draught Suction pipe<sup>(6)</sup>

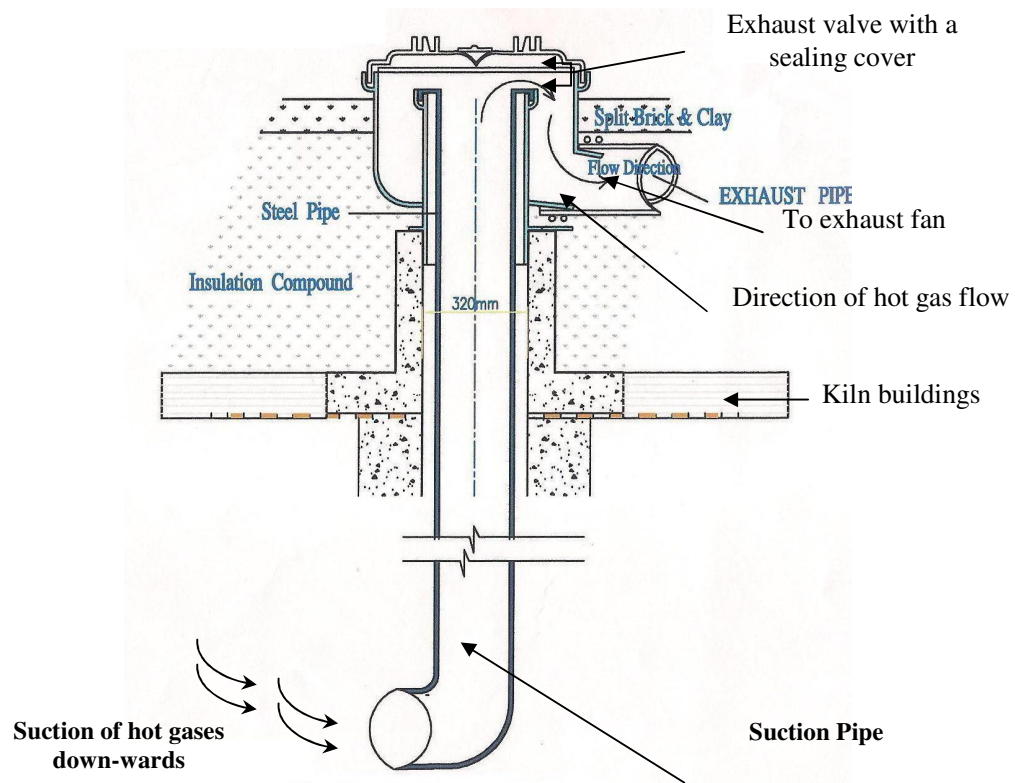


Figure 4 Suction pipe<sup>(6)</sup>

The first set group has to be inserted at the top of the stack, the second at the middle, and the last one at the bottom of the stack as shown in Plate 2. After the kiln firing-process had been finished, the three sets

were collected in order to examine the deformation and the effect of heat on them as shown in Plate 3.

**The Effect of heat & Deformation At the top of the stack**



Seger cones having a melting temperature of 950°C was semi- melted, that having 830°C was melted, and the one having 700°C was totally melted.

**At the middle of the stack**

Seger cone having a melting temperature of 950°C was not affected, the one having 830°C was melted, and the last one having a melting temperature equivalent to 700°C was totally melted <sup>(9)</sup>.

**At the bottom of the stack**

Seger cone having a melting temperature equivalent to 950°C was not affected, the one having 830°C was semi – melted and the last one having 700°C was melted.

**Results and Discussion**

The results are given in Table 2. As can be seen from Table 2, there is a small variation in temperature readings at the top, middle, and the bottom of the stack. The fired-bricks were found to be well-fired, having a similar color (red), with a reduction of bricks cracks (from 5% to 3%). As shown in plates 4 and 5.



Plate 1 The position of the seger cone between stacked bricks inside the kiln



Plate 2 The three groups of seger cone before firing

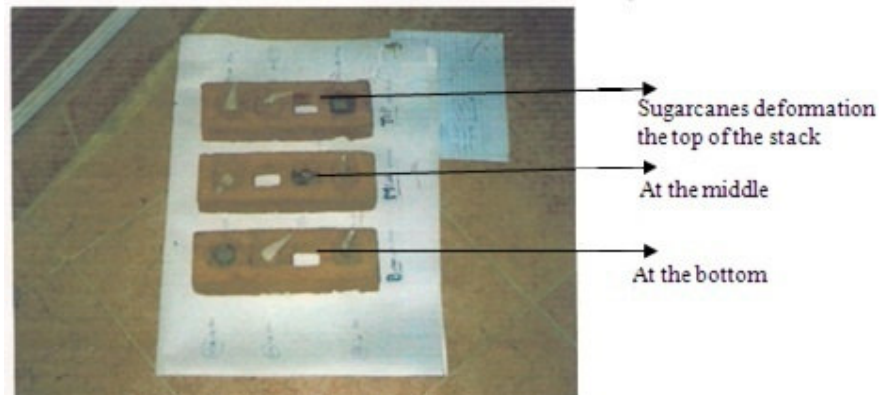


Plate 3 The effect of Heat on the segers

Table 2 Seger cone evaluation results

Seger cone set position	Equivalent temp.	Brick quality
At the top of the stack	950 C <sup>o</sup>	Well fired with red color
At the middle of the stack	830 C <sup>o</sup>	Fired with red color
At the bottom of the stack	830 C <sup>o</sup>	Fired with red color



Plate 4 Fired red bricks before using the suction pipes (Faint Red Color)



Plate 5 Fired red bricks after using the suction pipes (well fired with red color)

### Conclusion

To improve the existing Soba upper-draught kiln, special re-designed heat suction-pipes were used to join the bottom of the kiln with the main exhaust system. Their function was to draw and distribute the heat concentrated at the kiln top-crown downward to the bottom of the kiln in order to maintain heat balance within the kiln. The outcomes of this modification could be summarized as follows

- High temperature concentration at the kiln top-crown had been drawn and distributed evenly down-wards resulting in a heat balance inside the kiln.
- Stacks of bricks had been fired similarly in red color.
- Reduction in fired-bricks cracks and losses.
- Upper-draught kiln had been simply converted to function as an efficient down-draught one.
- The modification had been done without affecting the kiln building structure.

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