

## Modernization of Pusher Type Furnace #2 and #3 at Erdemir, Ereğli, Turkey



**Reining Heisskühlung**

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# Pusher Type Reheating Furnace Modernization

## PTF #2 and #3 at Erdemir, Eregli, Turkey

The iron and steel company Erdemir operates three pusher type furnaces within their 2nd hot strip mill at Eregli, Turkey. The furnaces are used for reheating of slabs for coil production.

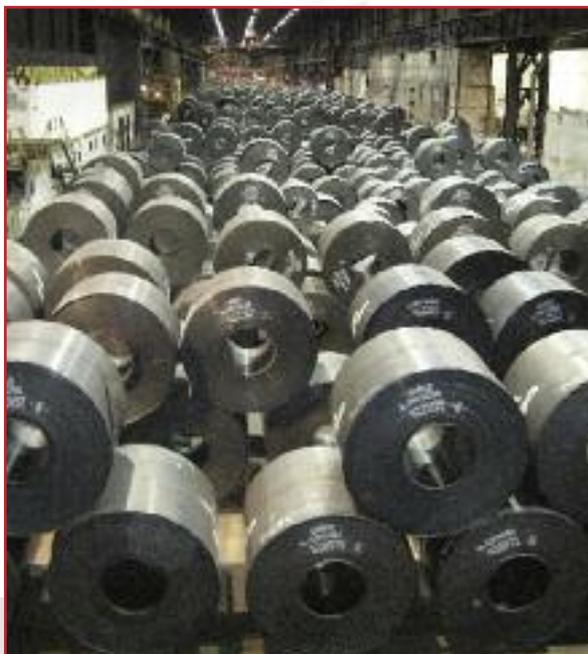
### Challenge

Before modernization the pusher type furnaces #2 and #3 were the bottleneck of the 2nd hot strip mill production line. The overall aim was the increase in productivity of the hot strip mill and therefore the increase in productivity of the furnaces #2 and #3.

The strategy consists mainly of three key points:

- Improvement of product quality
- Increasing of the furnace working capacity
- reducing of repair and maintenance efforts

The improvement of the product quality was the main goal of the project to reduce the reject quota in the production process. For that purpose the surface defects on the coil caused by scratches that occur during the furnace campaign had to get minimized as well as the thickness deviations caused by temperature inhomogeneity of the slab.



These inhomogeneities happen along the length and thickness of the slab and are further caused by the skid mark effect.

For the increasing of the furnace capacity a higher throughput is necessary. To yet reduce the specific energy costs the reheating of the slabs had to take place in a more efficient way with minimized energy losses in the cooling system, the offgas and the furnace walls.



Erdemir factory site in Eregli, Turkey

To drop the repair and maintenance costs and to maximise the availability and production time of the furnaces the service life of maintenance intensive parts like the skid system and the refractory had to get increased.

Especially serious vibrations of the skid system that occur during the charge of thick slabs should get reduced.

To detect the state of the furnaces and to define the guarantee values for the modernization a performance test was carried out before and after the furnace revamping. Therefore a reference slab was equipped with thermocouples and a data logger and sent through the furnace.

A more detailed description of the performance test is stated on the next pages.

Coil storage area

### Strategy and solution

A key step of the project was the removing of the ceramic hearth of the soaking zone. The hearth was identified as responsible for scratches which caused surface defects on the coils. On PTF #2 the rear part of the burner bridge and on PTF #3 the whole burner bridge was removed. The so gained volume of the soaking zone is now used for an additional heating area equipped with 2x2 new long flame side wall burners at PTF #2 and 2x6 flameless side wall burners at PTF #3. Despite the total available power is higher than before the revamping, the designed working point is lower than the original installed power. To control the new burners Level 1 control programs have been created and adapted to the existing control system. Furthermore Level 2 heat optimization models are renewed and taken into operation. The aim of the heat optimization is the increase of efficiency and the reduction of the specific energy costs.

In that new soaking zone the 8 skids are extended and featured with an offset to change the position of contact between riders and slab to reduce the skid mark effect and to improve temperature homogeneity.

In addition to that new design high cobalt alloyed riders with an increased distance between skid pipe and slab have been mounted in the soaking zone. For further homogeneity improvement the skids in the preheating and heating zone are equipped with metallic riders.



Prefabrication of skid pipes



Installation of the steam drum

The whole skid system is reinforced and cooled by means of the REINING evaporating cooling system (ECS) in a natural circulation.

Modular type of high efficient skid pipe refractory is used to enable easy replacement and long service time.

Another aim was to reduce the serious skid vibrations at the entry of the furnace. For that purpose the carrier tubes of the skid system have been connected with a new tie back construction directly to the foundation of the pusher.

To reduce pressure drop and heat losses in the furnace the old motor driven door was replaced by a new hydraulic driven door without water cooling.

During the 30 years lasting operation period the load carrying bottom steel construction has been wear out through corrosion, wherefore this structure has been renewed as well.

# Pusher Type Reheating Furnace Modernization

PTF #2 and #3 at Erdemir, Ereğli, Turkey

## Performance Results

After recommissioning a performance test was carried out in the same way as before. The comparison of the results shows improvements on all aspects. The guarantee values are all met or even outperformed.

The accomplished modifications lead to a very homogeneous temperature distribution in thickness and length of the slab. The skid mark effect is reduced significantly up to 75 % - 80 %.

All critical parameters which determine the quality can be realized now in a narrow tolerance gap. The scratches that occur from the old ceramic floor of the soaking zone are reduced by approx. 80 %.

With these improvements the reject quota of the coils due to thickness deviations and due to surface defects is extremely reduced.

The overall more efficient energy usage leads to a reduction of the specific fuel consumption to reheat one ton charge by 10 % - 16 %. The new tie back construction reduces the vibrations that occur during slab charging significantly.

Due to that also damages of the refractory have been reduced. Besides this the lifetime of the skid system is increased as the new reinforced design is based on a fatigue strength calculation and due to eliminated corrosion and erosion problems (see ECS).

In the soaking zone the regularly ceramic replacement is eliminated and hence the maintenance costs and efforts are reduced.

The above mentioned long service life of the entire furnace system will bring the advantage of high availability of the furnaces with less maintenance periods and more production time.

Before modernization especially the thickness distribution along the length of the coils was kept in a predetermined gap. Taking this issue into consideration due to improvement of the skid mark effect the furnace working capacity has been increased by about 13-18 %.

According to customers statement the improvements on both furnaces lead to a total capacity increase of 10 % in the 2nd hot strip mill at Erdemir.

As an welcomed by product the cooling system of each furnace delivers approx. 10-15 t/h saturated steam into a 16 barg steam net.



Preinstallation of pipework



Skid system installation



Skid system with new refractory shortly before recommissioning

### Evaporating Cooling System (ECS)

- no water based corrosion problems inside skid pipes due to use of treated boiler water
- no gasside corrosion due to operation above the dew point temperature
- less primary energy consumption due to smaller temperature difference between furnace atmosphere and cooling medium of skid pipe (reduction of cooling system related heat losses by 10-15%)
- each point of the cooling circuit has the same constant temperature independent from thermal load that leads to reduction of thermal stress in material
- natural circulation = no circulation pumps, saving of electrical power
- use of steam

### Rough project schedule

From contract award up to hot commissioning the modernization projects were realized within approx. 10 month considering following main steps:

- ~ 9 month for engineering and prefabrication
  - ~ 2 month of pre installation
  - ~ 1,5 month furnace shutdown incl. cold and hot commissioning
- Hot commissioning PTF #2: May 2012  
 Hot commissioning PTF #3: June 2014

# Performance test

## Guarantee values measurement and determination

### Performance Test

For the performance test a test slab has been equipped with thermocouples and a data logger and sent through the furnace.

The measurement equipment was insulated properly to survive the high temperatures. The test was executed before and after the revamping under similar furnace operation conditions. The furnace had to work in a

and a thickness of 225 mm and was made of low carbon steel. It was heated from 20°C to approx. 1.200°C.

In the picture below the position of the thermocouples is visible. Every position has a thermocouple at the top, the core and the bottom to measure the temperature distribution across the slab thickness. To obtain the

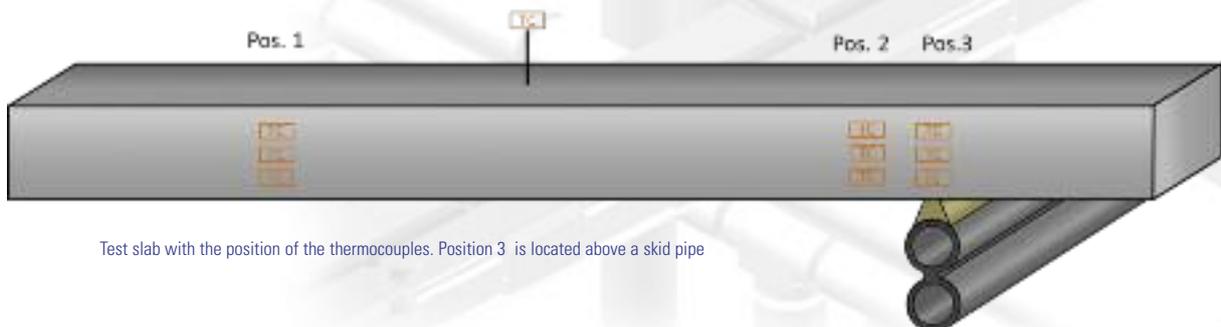


Prepared test slab with thermocouples and data logger is about to enter the furnace

continuous and stationary production and prior to the test at least 8 h on the same temperature set point level. The acceptance test was done in accordance to German standart VDEh No.545 including a tolerance on all data of 5 %. The test slab had a length of 12.000 mm, a width of 1.280 mm

temperature homogeneity along the slab a positioning at Pos.1 and at Pos.2 is necessary. Pos.3 is located above a skid pipe to indicate the skid mark effect that is calculated with the temperature difference of the bottom thermo-

$$\text{Skid mark effect} = \min\{\text{Pos.1}; \text{Pos.2}\} - \text{Pos.3}$$

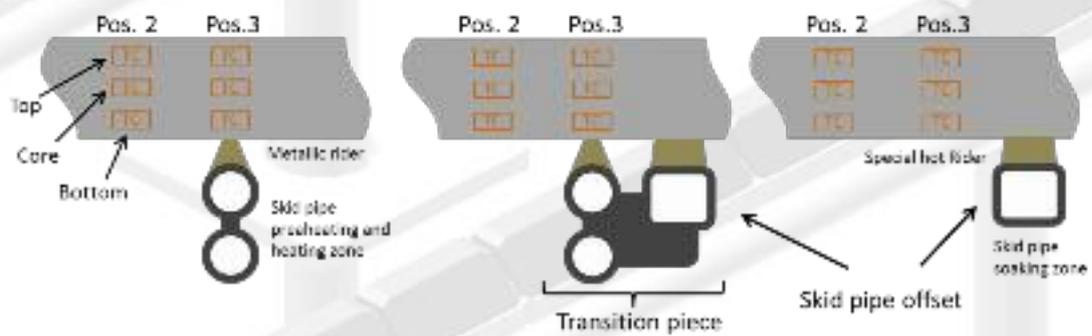


Test slab with the position of the thermocouples. Position 3 is located above a skid pipe

One thermocouple in the middle above the slab measures the furnace temperature.

As already mentioned the skid pipes are featured with an offset at the transition to the soaking zone. After passing the offset, Pos. 3 is no longer located in the shadow of the

skid. Now that area of the slab is undisturbed and gets no longer cooled with the result of an appropriate reduced skid mark effect. This is visible in the graphs on the next page.



Skid pipe offset in the soaking zone and change from double-round-pipe with metallic riders to rectangle pipe with special high cobalt alloyed riders

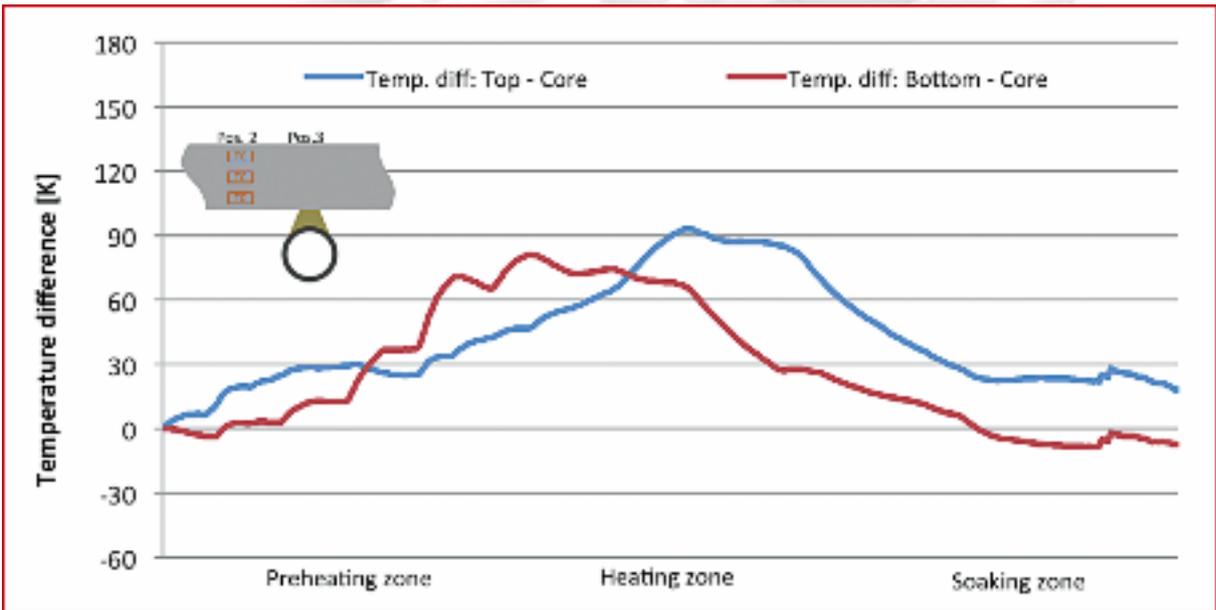


The test slab gets taken off the hot roller table to remove the measurement equipment

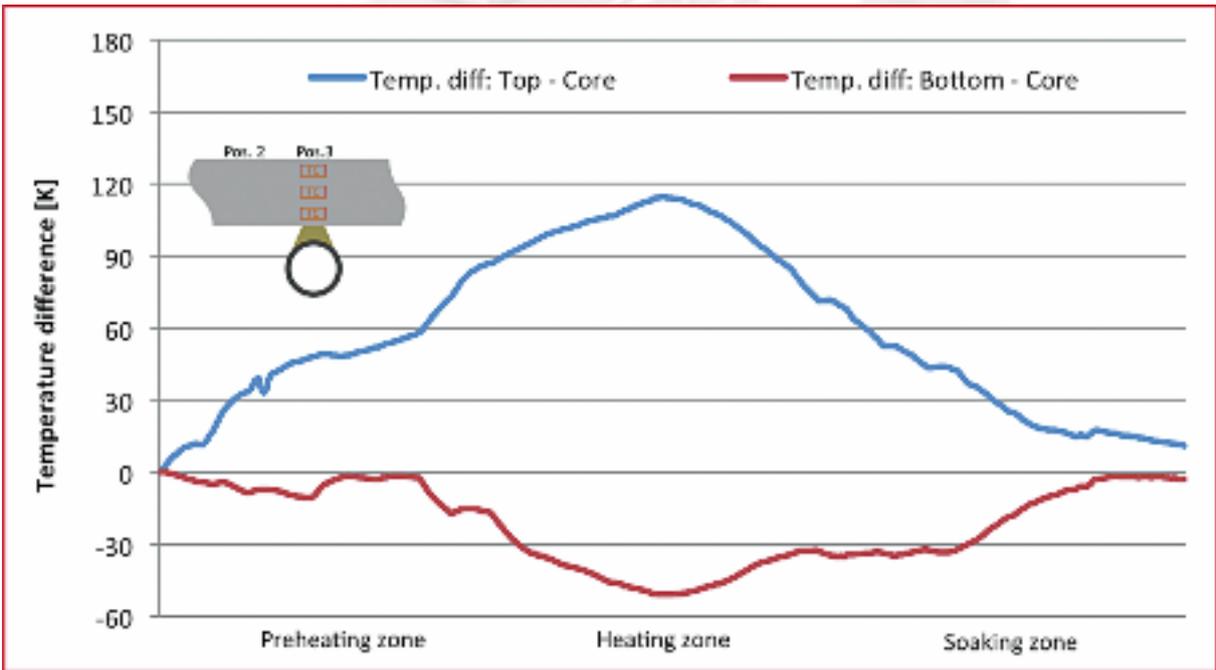
# Typical Slab Temperature Differences

Performance test measurements PTF #3

## PTF #3 before revamping

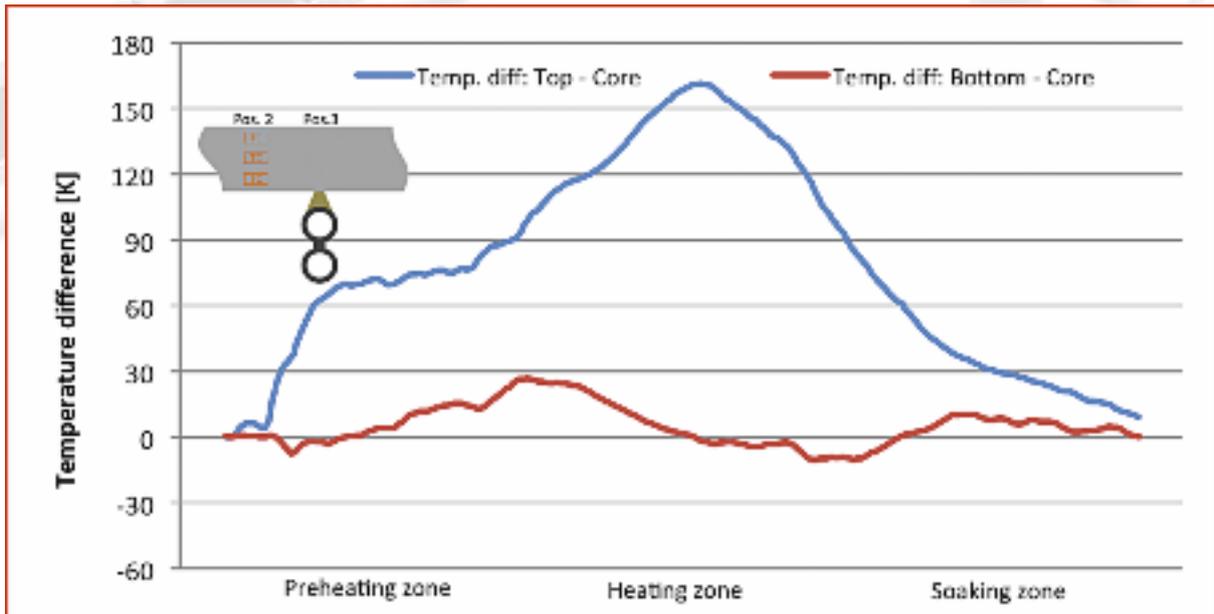


Slab temperature difference between top and core & between bottom and core during furnace campaign before revamping. Measurement at pos.2 (undisturbed point, no skid shadow)

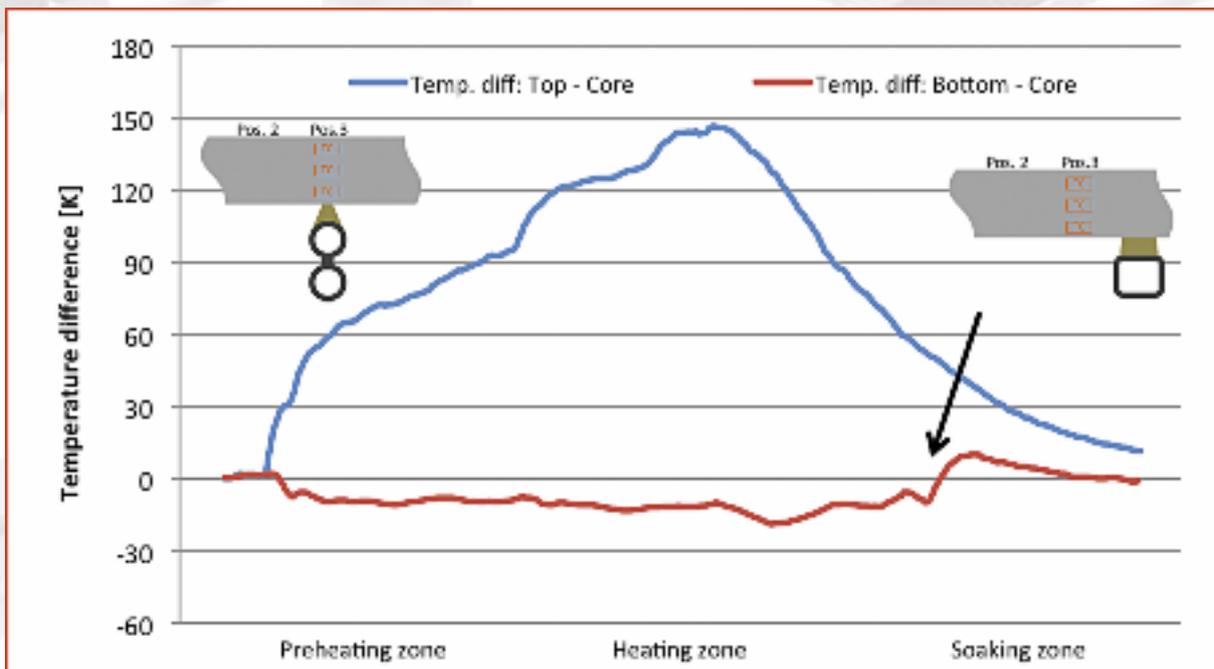


Slab temperature difference between top and core & between bottom and core during furnace campaign before revamping. Measurement above skid pipe at pos.3.

### PTF #3 after revamping



Slab temperature difference between top and core & between bottom and core during furnace campaign after revamping.  
Measurement at pos.2 (undisturbed point, no skid shadow)

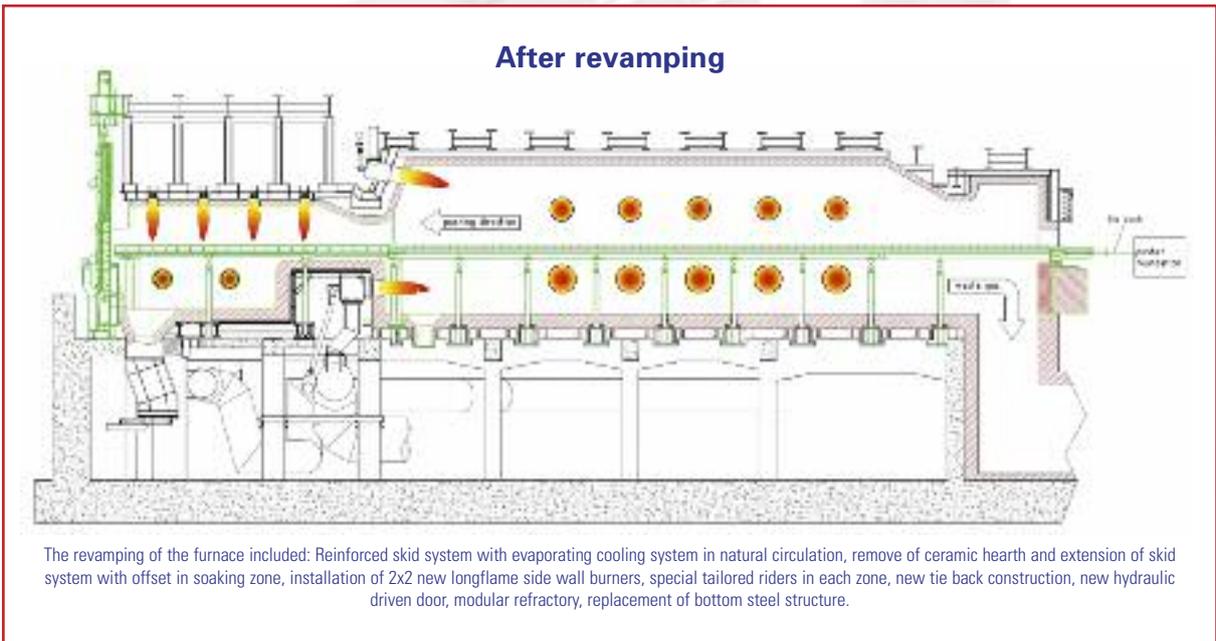
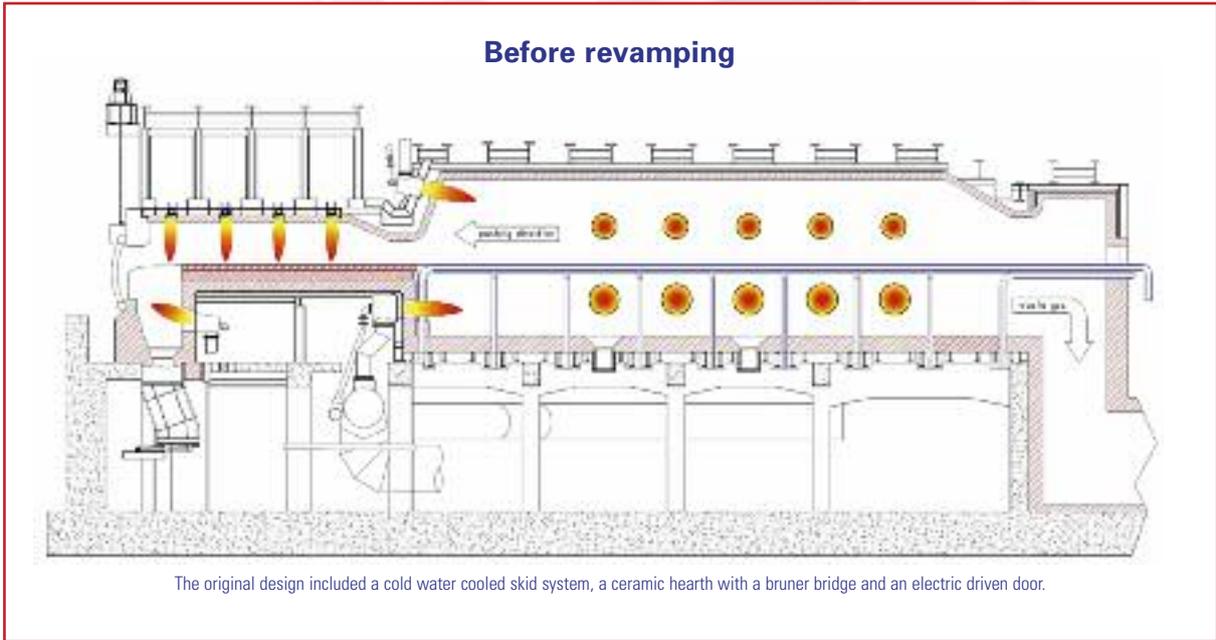


Slab temperature difference between top and core & between bottom and core during furnace campaign after revamping.  
Measurement above skid pipe at pos.3.

# Furnace Layout Drawings

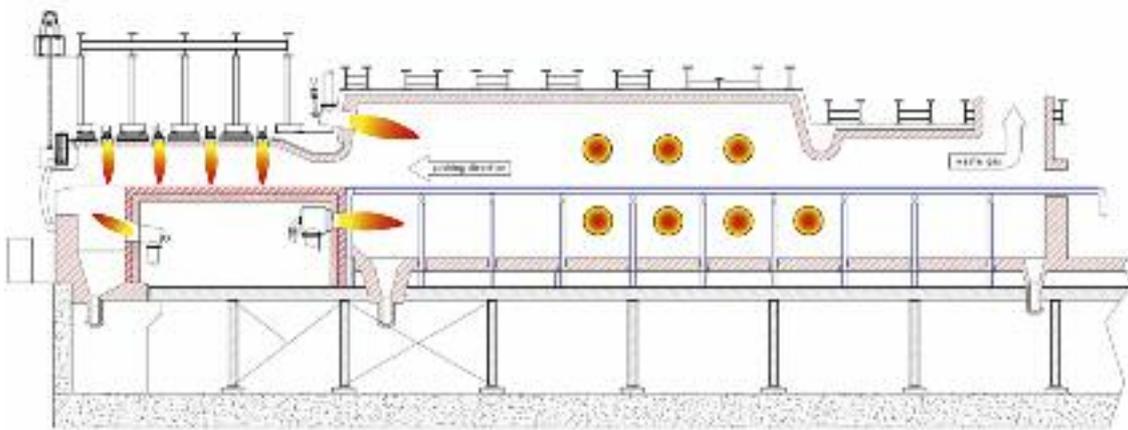
PTF #2 and #3 before and after revamping

## Layout PTF #2



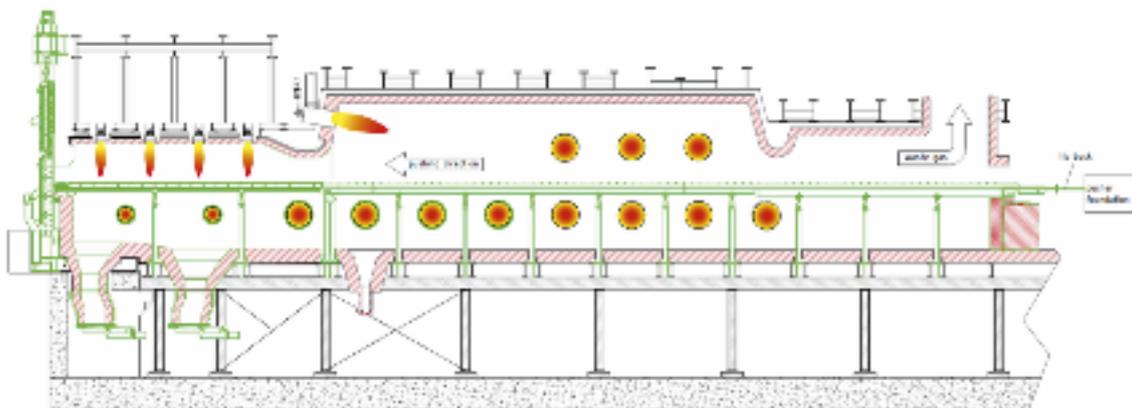
### Layout PTF #3

#### Before revamping



The original design included a cold water cooled skid system, a ceramic hearth with a burner bridge and an electric driven door.

#### After revamping



The revamping of the furnace included: Reinforced skid system with evaporating cooling system in natural circulation, remove of ceramic hearth and burner bridge and extension of skid system with offset in soaking zone, installation of 2x2 new flameless side wall burners, special tailored riders in each zone, new tie back construction, new hydraulic driven door, modular refractory, replacement of bottom steel structure.



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