TOP COMBUSTION STOVE TAILOR MADE HOT REPAIR*

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Abstract

The common hot blast stoves with internal combustion chamber operated satisfactory up to hot blast temperatures of approx. 1250 °C and the blast limitation of 280.000 Nm3/h. Thus, the design of these stoves only differed slightly from each other until the moment when the demand for higher efficiency of blast furnace operation required higher hot blast temperatures, for that, a top combustion stove design represents one of the options. The reason for the development of this kind of stoves was the former weakness of stoves with internal combustion chamber, especially in the area of the combustion chamber / checker chamber division wall. The idea was basically to avoid the division wall at all. Top Combustion Stove Hot repair was never done anywhere in the whole world until the first repair done in Sept, 2018 with success and zero accident, ensuring life campaign for the equipment under safe operational conditions. To overcome the problems of stove shutdown, DOMINION DEUTSCHLAND GmbH (Ratingen, Germany), DME ENGENHARIA (Belo Horizonte, Brasil) and partners introduced to the market a pioneer methodology due to the need of a short time for this revamping. The proposal of this paper is to show how important is to keep stoves lifetime in between 25 to 40 years campaign avoiding cooling down procedure, which drastically compromises the stove life at each occurrence.

Keywords: Top Combustion Stoves; Energy Efficiency; Hot Blast Stoves life campaign; Shaftless Hot Blast Stoves.

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1 INTRODUCTION

The purpose of the hot blast stove is to continuously add heat to blast air to a blast furnace that would otherwise have to be produced by burning coke. Thus, a coke savings (coke rate) is realized. In addition, high blast temperature intensifies and speeds combustion in front of the tuyeres.

A hot blast stove is a regenerative heat exchanger which is alternately heated then cooled as its gives up heat to the blast air. During combustion phase (heat accumulation), heat energy in hot exhaust gas from a burner is accumulated in the checker bricks and in the blast phase, a large quantity of hot air is blown through the checker bricks to raise the temperature of the blast air.

We should always consider that a hot blast stove failure, in most cases, is directly connected with a blast furnace shutdown.

2 HOT BLAST STOVES DESIGN WORLDWIDE AND ITS PARTICULARITIES

Pig iron produced by the Blast Furnace is the leading provider of raw material for the production of crude steel worldwide. During the last decades technological advances have enabled a substantial growth in the average size and production capacity of a single blast furnace and its peripherals.

This development substantially increased the pressure to extend Blast Furnace campaign, especially for the hot blast stove plant.

Being recognized as the main blast furnace peripheral, we should always consider that a hot blast stove failure, in most cases, is directly connected with a blast furnace shutdown.

The current hot blast stove plant has 3 or 4 units and is known for the following designs:

1. Internal combustion chamber stoves with metallic or ceramic burner capable of operating blowing temperatures up to 1200ºC;
2. Internal combustion chamber stoves with self-supporting dome (mushroom type), with ceramic burner, capable of operating blowing temperatures up to 1250ºC;
3. External combustion chamber stove (Mohr-Didier type or simply Box Girder type), with ceramic burner, capable of operating blowing temperature up to 1300ºC;
4. External combustion chamber stove (KK type) with ceramic burner capable of operating blowing temperatures up to 1300ºC;
5. Shaftless stove (Kalugin type) capable of operating blowing temperatures up to 1400ºC.

Below image with the different stoves design in operation worldwide.

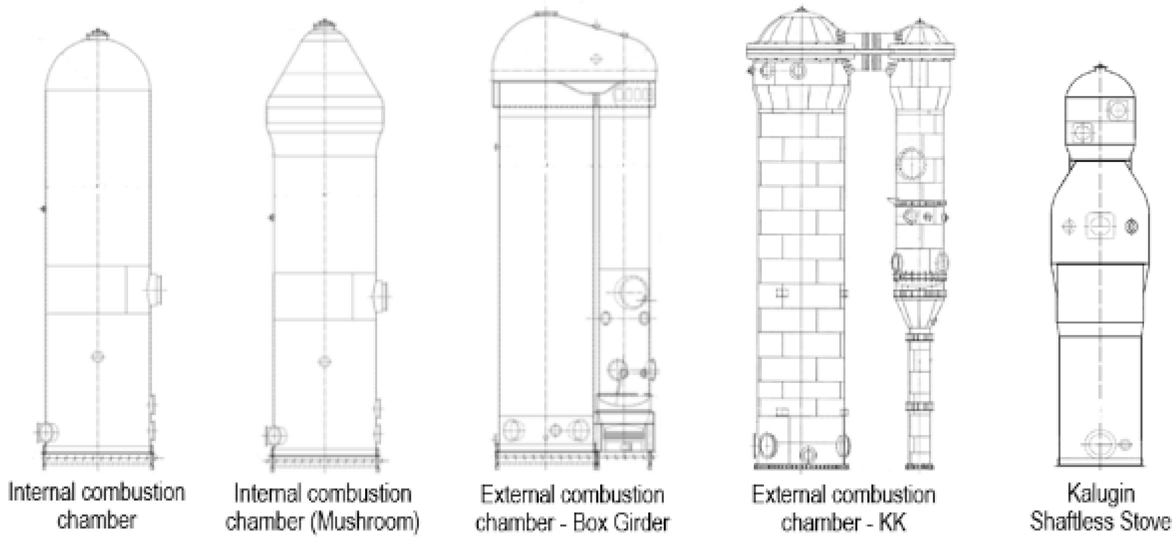

Figure 1. Typical Hot Blast Stoves Design Worldwide.

2.1 Internal combustion chamber stoves

Both the checker chamber and the combustion chamber are located within the same shell, thus creating the particular need for a refractory division wall between the combustion chamber and the checker chamber. The thermal deviation between the combustion side and the checker side generates the main equipment shutdown events due to occurrences of “short circuit” phenomenon and division wall “banana effect”.

In the lower part of the combustion chamber is located the burner, which during the combustion process generates energy through a vertical column until it is retained by the checker bricks, ensuring high temperature blowing during the blast cycle of this energy to the blast furnace.

It is the main type of existing hot stove around the world, with two distinct models, as shown below:

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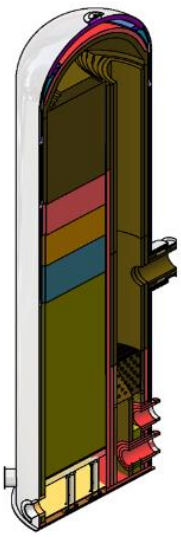

Figure 2. Internal Combustion Chamber Stove. Dome resting in the ring wall

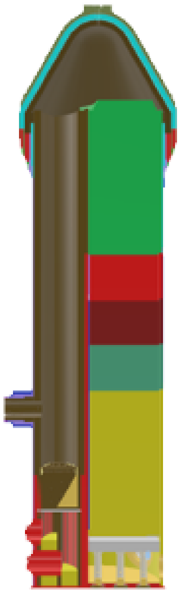

Figure 3. Internal Combustion Chamber Stove. Self-supporting dome

2.2 External combustion chamber stoves

External combustion chamber stoves are mainly characterized because the combustion chamber is arranged in a separate shell, thus creating a better load distribution between the combustion chamber and the checker chamber. The connection between chambers is made by an expansion joint for the model KK and by a metal frame known in the model as “Box Girder”.

In the lower part of the combustion chamber is located the burner, which during the combustion process generates energy through a vertical column until it is retained by the checker bricks, ensuring high temperature blowing during the blast cycle of this energy to the blast furnace.

There are two different designs, as shown below:

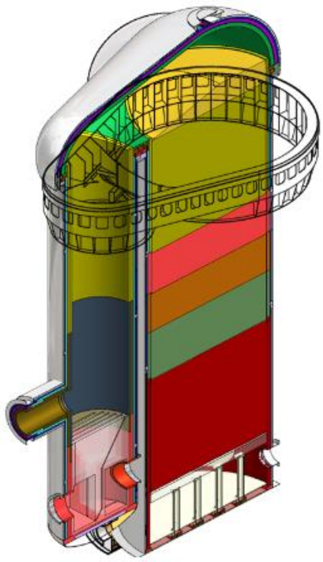

Figure 4. External Combustion Chamber Stove. Self-supporting dome

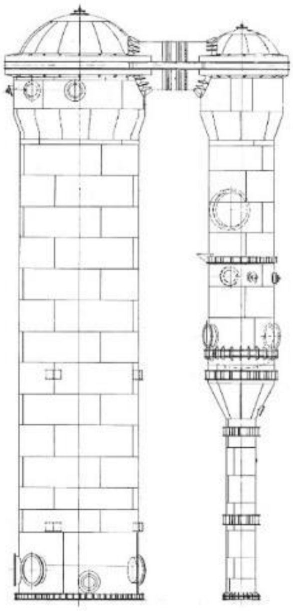

Figure 5. External Combustion Chamber Stove. Top expansion joint

2.3 Kalugin Shaftless Stove

The Shaftless hot stoves are characterized by having no combustion chamber, the burner is located at the top of the dome and above the checker bricks.

Phenomenon like “short-circuit”, “banana effect”, pulsations and the Stress Corrosion Crack (SCC) is not taken into account by Kalugin JSC to this Stove design.

One of the main reasons for purchasing this equipment is its energy efficiency, being able to reach a blowing temperature of up to 1400ºC with maximum CO found in smoke gas concentrations not exceeding 50 mg/m^3. Its cost-benefit is also a differential, given the smallest big difference in weight compared to other models.

Figure 6. Kalugin shaftless stove

3 TOP COMBUSTION STOVE IMPLEMENTATION IN THE EXISTING PLANTS

Top combustion stoves represent a new technology for implementation in a new hot blast stove plant or retrofitting existing plants with a 30-year operation life campaign without further intervention.

The equipment design can be used in Blast Furnace plants from 180m^3 to 5.000m^3 with dimensional adjustment only and without design change, since standard equipment is used.

The significant reduction in the equipment overall weight saves 30-35% in investment.
It is the only equipment on the market capable of reaching 1400ºC in blasting temperature, having a direct impact on coke rate reduction and reduced payback compared to other models.

It is always recommended to the greenfield or brownfield plants the top combustion stove feasibility study in view of the mentioned items and synergy with the operational life of the new Blast Furnace projects, which do not aim for major interventions in the hot blast stove plant.

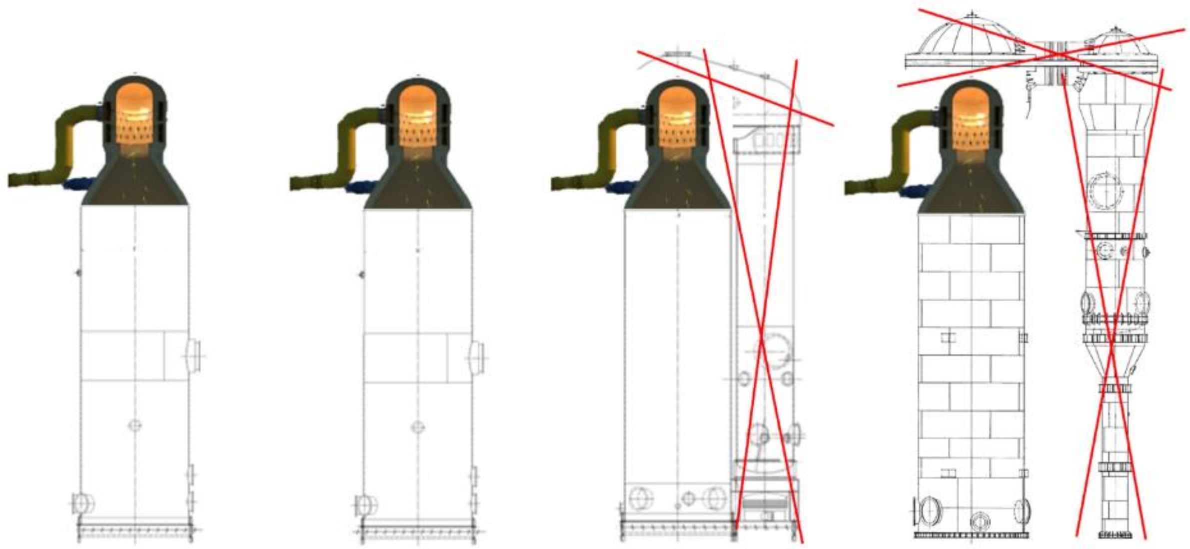

Figure 7. Top combustion stove existing plant implementation

4 TOP COMBUSTION STOVE HOT REPAIR

Top Combustion Stove Hot repair was never done anywhere in the whole world until the first repair done in Sept, 2018 with success and zero accident, ensuring life campaign for the equipment under safe operational conditions.

To overcome the problems of stove shutdown, DOMINION DEUTSCHLAND GmbH (Ratingen, Germany), DME ENGENHARIA (Belo Horizonte, Brasil) and partners introduced to the market a pioneer methodology due to the need of a short time for this revamping.

4.1 Tailor made repair methodology

The endoscope inspection of stoves to BF Plant revealed that there has been excessive damage to the hot blast outlet. The whole area to the hot blast outlet section and dome brickwork surrounding this area of the stoves suffered substantial damage. The repair was mandatory since the damages were in exponential evolution.

The stove plant is equipped with three hot stoves KALUGIN type. Silica refractory was used in the dome and top of checkerwork. The hot blast outlet of two stoves have been found damaged.

The observed damages (refer to visual inspection and endoscopy investigation) seem to have major influence on the present stoves lifetime leading to a BF shutdown, with no pig iron production, causing impact to the entire plant.

Considering a new Blast Furnace campaign of at least 15 years, customer has decided to repair the hot blast outlet at hot stoves using Dominion Deutschland GmbH/DME Engenharia hot repair pioneer technology.

4.2 Methodology development

In order to develop the repair methodology and keep stoves operating under safe conditions, five steps where established by the contractors since the earlier beginning, as follows:

- 4.2.1 Better knowledge about Kalugin Shaftless Stoves Design;
- 4.2.2 Definition of the correct repair methodology;
- 4.2.3 Evaluation of stove plant status, especially refractory conditions;
- 4.2.4 Definition of the project steps;
- 4.2.5 Project execution.

4.2.1 Kalugin Shaftless Stove Design

Kalugin shaftless hot stoves, designed stove without combustion shaft. The burner is located on top of the stove. Thus, according to their design philosophy, the Stoves eliminate the problems related with the division wall in the combustion chamber that typically occurs in the internal combustion chamber stoves.

The burner of "pre-chamber" type jet-vortex flow of gas and air is installed at the top of the dome. It provides almost full gas combustion before it goes to the checker bricks.

Combustion is finalised above the checker work where the highest temperatures are found in the transition from the dome to the cylindrical part.

Immediately after the top of checkerwork, the hot blast outlet is located. The area where the main damage was found. Right in the dome. Right in the area of the highest temperature inside the stove.

As shown in the **Figure 8** below, each area of Kalugin Shaftless Stove.

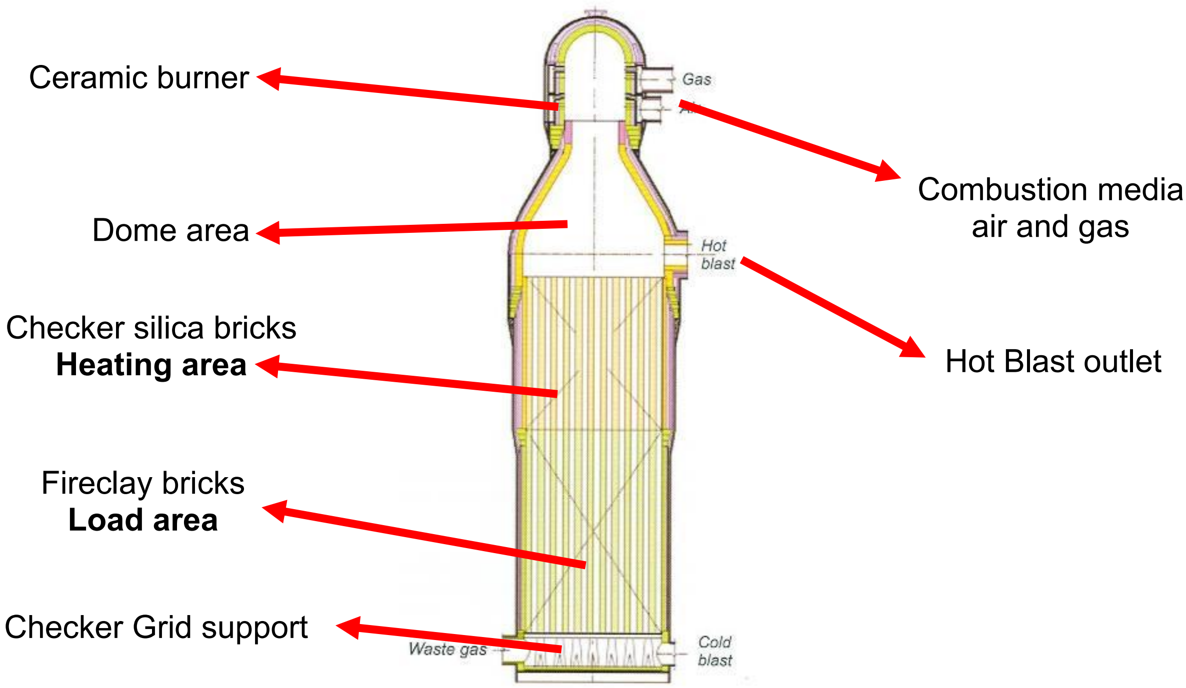

Figure 8. Kalugin Shaftless Stove design

4.2.2 Definition of repair methodology

The previous endoscope inspection of stoves to BF Plant revealed that there was excessive damage to the hot blast outlet. The whole area to the hot blast outlet section of the Stoves suffered substantial damage. During the stove repair is desired to make any and all repairs possible in order to prepare the stove that will be isolated from the plant during the hot repair.

Regarding the repair procedure, three possibilities were under evaluation. It is convenient to clarify that at any choice might occur a shutdown at each hot stove due to the repair period; it might reduce blast furnace performance during operation with only two hot stoves.

Due to the short time and safety aspects for this revamping, a hot repair was scheduled. Hot repair means that customer might have to reduce the hot stove dome temperature slightly prior to the Blast Furnace shutdown.

The scope of supply for the refractory repair covered the damaged area in the hot blast outlet where falling bricks and large cracks were found.

It was realized that might be not safe in an earlier stage to keep the damaged Stoves in operation.

The long and large hot blast outlet connection nozzle was represent a critical point because the limitations on work space. In these situations, we offer a technique to remove large pipes of a considerable size, cutting under hot temperature, in this case was cut of about 1.100ºC. The cut sawing can provide an ideal solution for many tricky or difficult applications like those that we have at the hot blast outlet connection nozzle, which is combining metallic and hot refractory cut at the same time.

.4.2.3 Evaluation of refractory condition

Figure 9, below, shows the construction of the hot blast outlet. The inner shaped ring consists of special bricks which are fastened in the brickwork in a way that they cannot be moved into the interior of the stove. The external profile of the shaped ring allows the installation of the dome bricks normally without any cutting.

The refractory lining of the hot blast outlet is made of brickwork and very special. This is part of Kalugin know how. Several problems were known in this area of the Stove where a leakage happens from the hot blast valve.

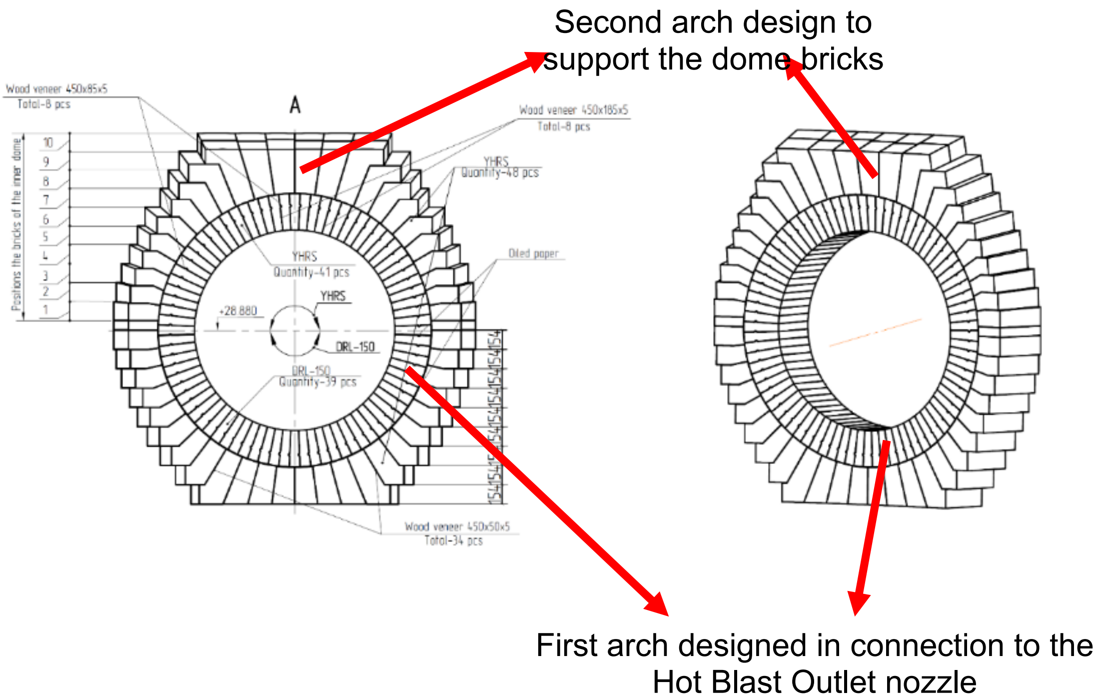

Figure 9. Kalugin Shaftless Stove Hot Blast Outlet design

4.2.4 Definition of project steps

After the customer acceptance to the hot repair methodology, the project was divided in six steps that was mandatory to have success during execution, without any accident and high quality, as follows:

4.2.4.1 Dissemination of repair steps to the whole group involved

Figure 10. Training to the whole group of companies

4.2.4.2 Correct choice of partners

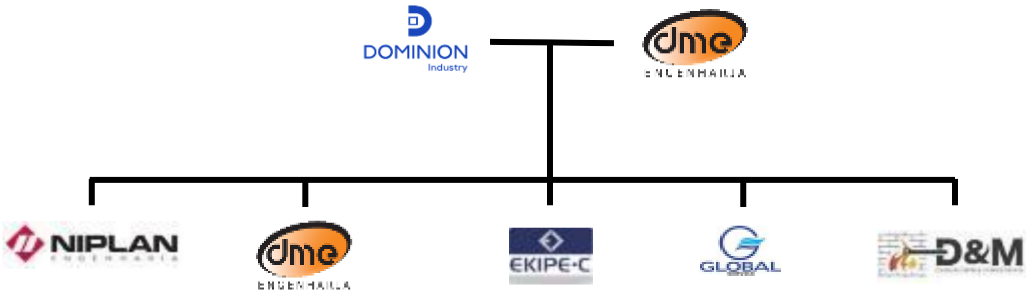

Figure 11. Project Organization Chart

4.2.4.3 Correct choice of manpower

Figure 12. Repair Team on site activities

4.2.4.4 Correct risk assessment to guarantee the stove under safe operation

To guarantee the project success without any accident, quality to the intend activities and keeping time schedule according to the planning, several number of meetings were appointed.

Our team was wearing an especial wear safety clothes provided to work under temperature of about 1.000ºC, wearing that especial protection they were able to perform the job under safety regulations and without any risk in the working area.

Every static calculation to the existing stove, refractory material, equipment, devices, safety equipment and clothes were under evaluation before the job starts in order to guarantee its application or its replacement.

Our Customer was well instructed with constants advices in order to guarantee the perfect synergy to the whole companies involved in the job.

4.2.5 Project Execution

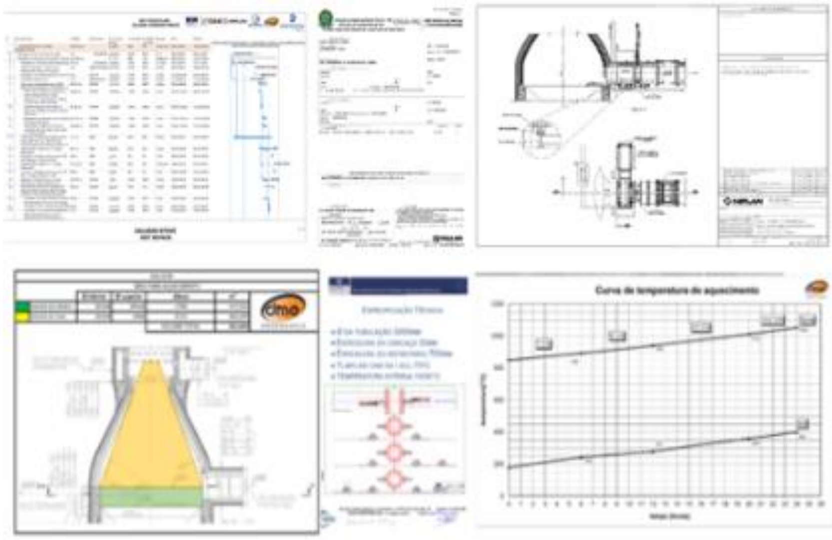

Figure 13. Full Package Project: Engineering, Supply, Management, Supervision, Services

Figure 14. Full Services: Engineering, Fabrication, Equipment development, wire cutting under hot conditions, Heating up and thermal comfort, eletromechanical and refractory activities

Figure 15. Jobsite activities

5 CONCLUSION

BF Plant is operating with three Kalugin at the stove plant. After a serious damage found in the hot blast outlet, Dominion Deutschland & DME Engenharia provided a method of partial hot repair to bring stoves back in operation under safe conditions again.

Top Combustion Stove Hot repair was never done anywhere in the whole world until the first repair done in Sept, 2018 with success and zero accident, ensuring life campaign for the equipment under safe operational conditions.

To overcome the problems of stove shutdown, a repair procedure was develop that allowed operating the stoves while the necessary hot repair activities take place. On dome combustion chamber stoves a refractory failure on the burner or in the hot blast outlet area for whatever reason will result in brickwork falling to the surface of the checkers, reducing the free cross section and blocking holes. Repairs in the dome and hot blast outlet area require a complete cooling down of the stove or a specific hot repair methodology that has to be done by experienced company.

The hot blast outlet connection nozzle was cut especially because the limitations on work space and time. In these situations, we are able to provide an ideal solution. The especial technique is one of the most efficient ways to remove large pipes of a considerable size under hot temperature, in this case was cut of about 1.100ºC. There is virtually no limit in terms of sawing depth. The cut sawing can provide an ideal solution for many tricky or difficult applications like those that we have at the hot blast outlet connection nozzle, which is combining metallic and hot refractory cut at the same time.

The stoves were heated using the auxiliary burner located in the dome manholes. An especial venture was developed and fabricated to attend the project located at the inspection manhole in the grid room.

Very especial wear safety clothes were provide to work under temperature of about 1.000ºC, wearing that especial protection our team was able to perform the job under safety regulations and without any risk in the working area.

Since the intermediate repair was done by gunning application, customer was advice to planning additional gunning application after a certain period if is realized that the material is not in position. Normally this material has a short lifetime mainly because of no anchors to support.

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