



The repair of the coke plant „Jadwiga” coke oven battery from the 10 years of the non-failure exploitation perspective

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SUMMARY

The constant monitoring of the technical condition of the coke oven battery and execution of the appropriate maintenance activities is one of the most important principle for prolongation of the coke oven battery exploitation life. The problem for discussion is always the method of repair according to the individual exploitation and economical situation of the coke plant. All repair methods have advantages and disadvantages and the outcome of the repair depends on many factors. This paper describes the complexity of the repair decisions and its outcome from today perspective based on the experience of the conducted 10 years ago the repair of the coke plant Jadwiga coke oven battery. The repair method is described in details and the modifications of the method based on the experience collected during the repair execution. It is also pointed out why this repair method and individual technological solutions were used.

Introduction

One of the most important elements of the proper operating of the coke oven plant is a proper investments and maintenance politics. It is especially dedicated for the most important coke making aggregate which is a coke oven battery. At the same time the maintenance decisions for the coke oven battery are the most complex to make. The progress in the maintenance and repairs techniques gives a full portfolio of the methods but on the other hand every battery needs unique approach to the issue of maintenance.

The common method of battery renovation is current coke oven brickwork maintenance and conservation or replacement of the battery fittings. The mentioned activities are typical and do not require abnormal technological activities and the only criterion of the execution is a type of encountered damages. In spite of this, during time the standard maintenance action starts to be insufficient for maintaining the production capacity. In such cases the only option can be partial or full replacement of the ceramic brickwork along with battery fittings or decommission of the battery. In such case the framework of repair need to be consider, having on mind time, costs and various other issues like construction or technological details.

It is worth to be mentioned that such methods do not have precious technological solutions and many times need to be modified according to the situation which has no place during the standard maintenance activities.

The complexity of such a repair methods was especially revealed during the Jadwiga's coke plant coke oven battery renovation. From the perspective of last 10 years of failure free operation of the battery it must be stated that the decisions taken then were right.

Coke oven battery repair method conception

In 2004 coke plant Jadwiga was operating only one coke oven battery commissioned in 1968. Every coke oven chamber of that battery was already after approximately 14.000 cycles with assumed lifespan of 10.000 cycles. The undertaken maintenance activities were more often and wider in range and on the same time the heating flues technical condition rapidly de-





crease worsening or precluding the firing gas combustion.

The advanced battery age and natural degradation, that shortaged rapidly the production capacity, with good condition of the rest of the facilities put on danger further operation of the plant. In this situation, having on mind the literature information (for ex. [1], [2]) about rapid production decrease because of the battery technical condition worsening, the build up of the new coke oven battery was taken under consideration. It must be stated here that for one battery plant the build up of a new battery on the place of the old was out of question because of: concerns about the restart of the battery and by product treatment plant, agreements for coke delivery and no perspectives for coke plant workers during investment time. The location (not enough space) and financial restrains and lack of permission for build up from city authorities finally put the build up of the new battery in the coke plant "Jadwiga" out of the question. In this situation 3 conceptions evoke:

- maintain of the current repair politics based on the immediate maintenance and replacement of the destroyed brickwork during hot repair,
- conducting of the through wall nests repair,
- replacement of the hole brickwork in flow repair.

According to the technical condition of the coke oven battery the first option was equaled with closing of the whole coke plant in a short period of time. The second option was connected with risk of destruction of the part of already rebuild walls because of need of another cooling down during another part of the brickwork rebuild.

So according to this only the flow repair was justified. The flow repair depend on the replacement of the whole brickwork in parts from one abutment to another and the following stages of the repair was introduced simultaneously on the few groups of ovens with maintaining the production on the remaining ovens.

The practice says that the success of that repair is based on the large risk and demands complicated technological activities, but from the coke plant point of view it was the only possible solution. The decision was also based on

following arguments: the comparable technical condition of the all heating walls demanding immediate replacement, coke production demands, no external gas supplier and guaranteed supply of the silica of the stable properties.

Taking into account the current battery technical condition and expected outcome of the repair and possibility to maximize the recovery of the battery fittings it was established that the whole chambers, battery bottom and the upper part of regenerators will be replaced. It was also establish to recovery 75 % of the regenerators filling and replacement, if necessary the battery fittings such as backstays, springs, armors, doors, beams. The following activities were also executed: the replacement of the leaky air-waste gas valves plates and reversing valves corpuses, grinding of the reversing valves hearts, replacement of the ascension pipes refractory and reinforcement of the backstays in the service platforms area. Having on mind a role of abutments during the heating up of the repaired brickwork and stress connected with thermal expansion of the silica it was decided to hammer the crown of the abutments reinforced it and pored with concrete again. It was also decided to replace the led plates on the longitudinal beams for 3 spring sets that guaranteed the load of 360 kN per beam.

Analyzing all conditions and time needed for chosen repair method, allowed production decrease to 40 ovens per day and coking cycle ~21h, it was decided to divide a individual repair for 4 walls repair nests. The schedule for all nests was as followed:

- cooling stage 10 days,
- demolition stage 10 days,
- rebuild stage of 4 walls by two masonry brigades with additional brigade for regenerators refilling 35 days,
- heating up stage 25 days (with standard 2% expansion silica).

It was also assumed that some stages will be performed in the following nests at the same time to short time of repair:

- cooling stage for nest n+1 will be covering the end of the rebuild stage on the n nest,
- the cooling and demolition stage for n+1 nest will be covering the heating up stage for nest n.

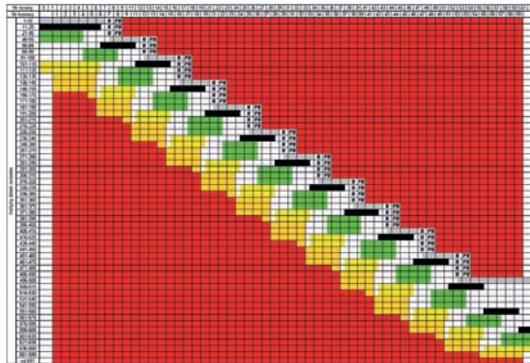




Taking into account the condition of the firing and operating the ovens near by repair nests and construction of the battery bottom the different way of processing was developed for first repair nest

- cooling stage of abutment wall and heating walls 1-7 (wall No. 7 only partially),
- demolition stage of abutment wall and heating walls 1-6 along with battery bottom,
- rebuild stage of the battery bottom, abutment wall and heating walls 1-4.

Such a Schedule of repair gave the guarantee to finish the rebuilt of 54 chambers of the battery within the 660-690 days with maintaining the assumed production of the battery (fig. 1).



cooling down demolition rebuild heating up
 optimization of the firing normalna eksploatacja
 B – Buffer oven (out of service) PB – half Buffer (operation on the longer coking cycle)
 Fig. 1 The Schedule of flow repair of the battery in coke plant „Jadwiga”

Cooling down and demolition stage

Cooling down stage was performed in the same way for all repair nests. The cooling stage enclosed the heating walls, battery bottom and regenerators for the parts of brickwork designated for rebuild and the nearby walls (buffers and half buffers). The chambers designated for rebuild were permanently cut off from collecting main shortly after coke pushing and the ascension pipes were dismantled. At the same time in the buffer chamber 5 strut walls were build which made possible to service the half buffer chambers with 1,5 coking cycle. During the following cooling down days the collecting main bearings (fig.2) and the upper parts of the buckstays (fig. 3) were reinforced and repair nest was roofed and the pathway over the nest was build.

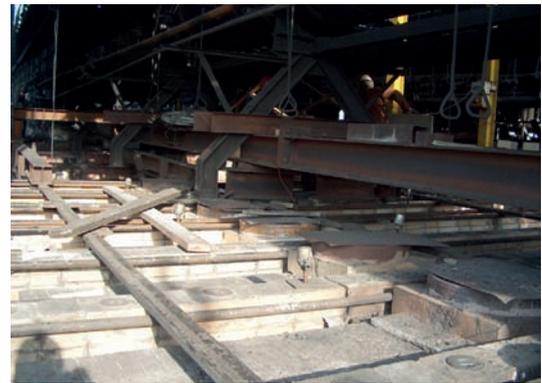


Fig.2 The view of the reinforced collecting main bearings.

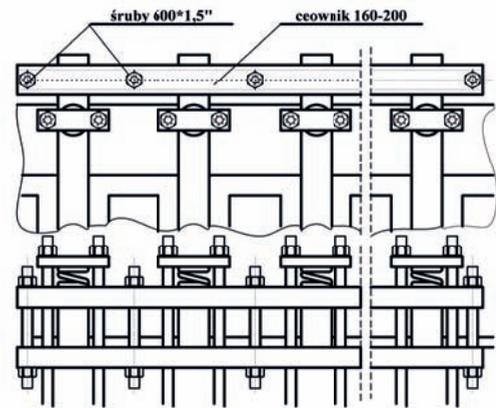


Fig.3 The draft of the reinforcement of the buckstays

The actual cooling down process was conducted according to the presented schedule (fig. 4) and achieved by following adjustments:

- stepwise decreasing of the firing gas feed and stepwise increasing of the air feed to the cooling down heating walls,
- the complete shut down of the cooling down walls firing after achieving the temperature in the head heating flues ~900°C
- opening of the ascension pipes holes after achieving 600-700°C,
- opening of the heating walls inspection holes covers in case of the delays,
- opening of the coke oven doors for the nearby chambers in the last stage of cooling down (8-th day).

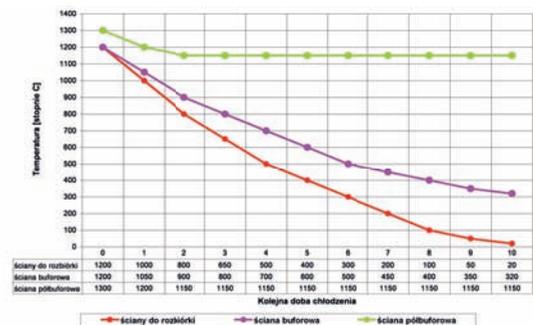


Fig. 4 Schedule for repair nest cooling down stage



In spite of all that, during the cooling down, the buckstays springs were stepwise loaded until full closing of the spring to minimize the tearing apart of the brickwork not designated for repair.

The standard tasks for demolition stage were removing of the brickwork, dismounting of the ovens fittings and buckstays springs but most important during demolition was the stepwise strutting of the free space of the repair nest on the roof and bottom level with use of the 14 heavy-walled struts Φ 120 mm. The reason was to counteract of moving the heating up or operating parts of the brickwork in direction of the repairing parts of the battery. In spite of that, during repair it was discovered that, despite of strutting, the brickwork was displacing anyway. To counteract the additional packages of the struts were mounted on the battery bottom level and on the battery roof level the additional mounted to collecting main bearings (fig. 5 and 6) struts were added. This, along with other technological activities, helped to maintain the designed chambers width.



Rys. 5 Widok rozpór montowanych na poziomie trzonu



Rys. 6 Widok rozpór montowanych na poziomie sklepienia

Rebuild and heating up of the heating walls

The rebuild of the heating walls was based on the technical documentation from 1965 but with some major modifications because of the specification of the repair and need of blend the new parts of brickwork with the existing base. It was connected with following elements:

- location of the level of chambers floor,
- hot length of the walls and way to achieve it
- width of some walls and scale of some chambers,
- making of some of the expansion joints and location of the sliding layers and mortar modification

One of the not typical issues for this battery was, confirmed by geodetic measurements, the deflections of the levels of the coke oven chambers, pushing machine railway and battery base slab caused by underground mining. The discovered deflections on the both longitude and lateral axis exceeding even 150 mm, forced assessment of the individual rebuild level for all repair nests. It was out of the question to rebuild the pushing machine railway level because of the need of servicing the old chambers during the production. On the start, for first 7 nests, the chambers floors level was depressed by 2-3 mm (from the previous nest level) with maintain of its level on the length of the battery by different joints dimensions in the battery bottom area. On the following nests the chamber floor levels were discretely established to counteract against the difference larger then 10-12 mm between real and expect level of the chambers floor. Such approach was dedicated by shifting of the rebuilt parts of the brickwork in the repair direction. As next observations showed such approach allowed to push and charge all rebuilt chambers.

The second major issue for this rebuild was need of a change of the length of the walls, because of the old regenerators' walls base. The old parts of the brickwork, because of the crystallographic changes, elongated on the layer R39 for about 200 mm and on the layer 7R for about 150 mm. In this situation, and what is more the buckstays deflection, the rebuild with the designed length of the heating walls was out of the question. After analysis and geodetic





measurements it was decided to elongate the heating walls despite of the up coming ceramic materials in original designed dimensions. The solution was to elongate the rebuild parts by 120 mm by incorporating into the wall the additional heads of the walls protective quartz-chamotte blocks (fig. 7). The spacing of the others elements of the ovens stood the same (heating flues, inspection holes, ascension pipes holes).

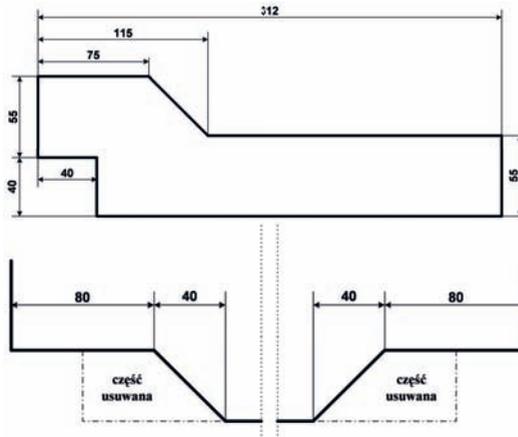


Fig. 7 Construction of the additional protective ceramic blocks and the method of assembly

At the same time, to reduce the buckstays deflection caused by difference between 39R and 7 R layers, additional spacing plates were mounted on the downward lateral beam.

It was not assumed to change width or height of the chambers or change the chambers scale. Unfortunately large shifting of the heating up parts of the brickwork in the direction of the old brickwork caused the shortage of the space for next rebuilds. In this case, in spite of the execution the countermeasures for these anomalies, it was decided to change some of the walls width by 5-10 mm and shift its axis location into the old part of the brickwork. Especially the axis shifting was very difficult because of a need of shifting already assembled buckstays. However, because of that action, it was possible to assemble the whole armors and coke chambers frames.

Because of the difference in the expansion of the new and old brickwork and to counteract the tearing of the joints during the heating up, two additional sliding layers were placed. The sliding layers allowed independent movement of the brickwork in the battery bottom, walls and between walls and roof of the battery during heat

up. The sliding layers were prepared according to the IChPW patent No. PL199403 from the graphite-gypsum mass blended with water to the dense cream consistence. Such a solution presented to be fully efficient, what was confirmed by geodetic measurements of separated by the sliding layers parts of the brickwork. Also there was no visible evidence of the tearing apart the joints in the roof area and after heating up the brickwork was absolutely airtight. At the same time, for ensuring the leakproofness of the brickwork, especially in the areas where wider joints needed to be used for leveling, the modification with phosphorous acid of the mortar was introduced. Also this solution proved to be very beneficial, not only because of ensured leakproofness but also by ensured stability during very hard masonry works (the schedule enforced very high working rate).

The most difficult problem for the repair were possibilities of temporary blocking of the expansion joints in the area that was buffer between heated and rebuilt parts of the brickwork, what was causing the movement of the unheated parts of the new brickwork to the direction of the old walls. Firstly used PCV plates with melting point around 110 °C probably were not enough pressed during heating up what with conjunction with not enough struts in the battery bottom area, caused shifting of the axis of the successively commissioned chambers. Because of the specification of the repair, expansion joints could not be left unsecured, so decision was made to fill them with sawdust pored by coal-tar pitch. This solution among others helped to restrain the early expansion joints closing.

The heating up of the rebuild parts of the brickwork was conducted in the same way as it is during the new battery start up. Firstly the heating up, up to 700 °C, was conducted through the temporary furnaces in the chambers during the one direction draft. The buffer walls for every repair nest were not heated. During this time the air-waste gas valves were disconnected from the reversion string and all valves were working on the downward stream. The innovative solution for this period was using, instead of traditional isolation walls, hanged on the frames isolation screens with a whole for the burner (fig. 8). This solution helped to improve





the commissioning works without any influence on the heating up process.



Fig. 8 View of the new solution for chamber isolation

As it is during heating up of the new battery, the changes of the diaphragms for firing gas feed, and drafts in the air-waste gas valves were adjusted according to the achieved temperatures in the control heating flues. During the whole period of the heating up process, the appropriate load on the heating up walls was maintained by adjustments of the springs mounted in the buckstays.

After achievement of the temperature in the heating flues on the level beyond 700°C the normal firing was started up and such chambers after appropriate reinforcement were put under normal operation

Current technical and technological condition of the battery

Currently the coke oven battery in the coke plant „Jadwiga” has 10 years of the failure free operation. The years when the coke demand on the market was fluid and the changes in the production capacity needed to be done, the battery repair outcome was checked under very extreme conditions.

Currently the maximal designed production capacity of the battery is achieved during the nominal 20,35 h coking cycle and the temperatures in the control heating flues on the level of

1320°C and can produce 280 thousand Mg coke per year.

Since the flow repair until today 161150 chambers were pushed giving 2 million tons of coke on the average coking cycle 25 h (from 20,35 to 39 h). Those years showed that in spite of production changes the battery can be maintained in good technical and technological shape. The average coefficients of the distribution of temperatures in the control heating flues achieved in years 2012 and 2013 were 0, 94 and 0, 93. All chambers of the battery operate in the normal cycles and do not show any serious faults. The inspection of the chambers brickwork showed that:

- chamber brickwork, in spite of years of operation, are in the good technical condition and maintenance (ceramic welding) is executed very rare (2-3 chambers per year) and mainly in the areas of the quartz-chamotte additional bricks,
- ceramic brickwork is airtight, there is no visible leakages of the crude coke oven gas to the firing system,
- battery fittings, in spite of not being replaced during repair, do not show the signs of abnormal exploitation (in the close time only the shackles of lateral beams need to be replaced because of corrosion),
- the gun flue firing system is in good technical condition and undergoes only the current normal maintenance.

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