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2nd RELINE OF ROGESA'S BLAST FURNACE NO. 5 IN DILLINGEN/SAAR, GERMANY[1]

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Abstract

In 2010 Rogesa executed a reline of its blast furnace No. 5 within a downtime period of 102 days. This report shows a very detailed description of the situation at ROGESA in Dillingen/Germany with regard to the operated blast furnaces and their performance during the different campaigns. The work which was carried out is shown thoroughly and the time schedule is explained. A major part in this report comprises the methodology of the erection of the new blast furnace shell. A specific topic amongst others is the installation of the new Paul Wurth BLT®GEN3 gear box to optimize the charging process and fuel consumption. Finally, the successful blow-in results are shown.

Key words: Blast furnace reline; Campaign life; Rogesa; PW BLT®GEN3 Gear

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ISSN 2176-3135

1 INTRODUCTION

The company of ROGESA (**Ro**heisen**ge**sellschaft **Sa**ar) is a joint venture for iron making of AG der Dillinger Hüttenwerke and Saarstahl AG. It is located in the southwest region of Germany at the site of Dillingen. ROGESA is operating two Blast Furnaces with an actual capacity of 4.7 Mt of hot metal per year. Blast Furnace No. 3 is at stand-by and is actually not in operation.
The following table shows the characteristic items of the three Blast Furnaces owned by Rogesa.

Table 1. Characteristic Data of Rogesa Blast Furnaces

	BF No. 3	BF No. 4	BF No. 5
Year of construction	1971	1974	1985
Restart after relining	2003	2003	2010
Reason of revamping	Reline	Enlargement	Reline
Nominal production	1800	6200	7200
Number of tapholes	1	2	2
Working volume	1270	2358	2934
Hearth diameter	8.5	11.2	12.0
Number of tuyères	20	30	32

Blast furnace No. 4 was restarted after enlargement in 2003.[(1)] The BF No. 5 was relined from July to October 2010 after its second campaign, which had to be interrupted by an interim repair in December 2005 and January 2006.

2 RESULTS OF THE SECOND CAMPAIGN

The following table shows the results of the two parts of the second campaign, which had to be interrupted by the interim repair in 2005. The following work was carried out:

- Replacement of the hearth wall carbon blocks.
- Replacement of the cast iron staves in the bosh by copper staves.
- Replacement of 10 cast iron tuyère staves.

This interim repair in 2005 had to be performed in an emergency because of the accelerated progressive wear of the hearth walls and the cast iron staves in the bosh leading to hotspots after 8 years of operation. Also after the interim repair the wear of the tuyère staves continued and in consequence the reline had to be done in 2010. The main cause for the wear was the use of low quality coke.[(2)]

ISSN 2176-3135

Table 2. Operational Data of the 1st period, 2nd period, and total campaign

		1st period	2nd period	Total campaign
Start		Aug.29th 1997	Jan.30th 2006	Aug.29th 1997
End		Dec.12th 2005	Jul 12th 2010	Jul 12th 2010
Time intervals		Before interim repair	After interim repair	total
Time duration	years	8.3	4.5	12.8
HM production	Mt	18.9	10.2	29.1
Total productivity	t/m³WV	7318	3570	10888
Production	t/d	6577	6335	6493
Productivity area	t/m² 24h	58.2	58.0	58.1
Productivity vol.	T/m³ 24h	2.55	2.45	2.50
Burden sinter	kg/t HM	1177	1079	1143
Pellets	kg/t HM	199	307	236
Lump ore	kg/t HM	207	198	204
Coke rate	kg/t HM	323	306	317
Small coke rate	kg/t HM	24	27	25
PCI rate	kg/t HM	128	143	133
Reductants total	kg/t HM	475	476	475

The results of the entire second campaign are satisfactory because after the interim repair the campaign could be extended to almost 13 years.
After blowing down the furnace was stopped on July 12th, 2010 and the salamander was successfully tapped giving a weight of 580 t of liquid iron.
After clearing of the hearth a dissection of the residual refractory was performed. The results of the measurements are shown in the following Figure 1.

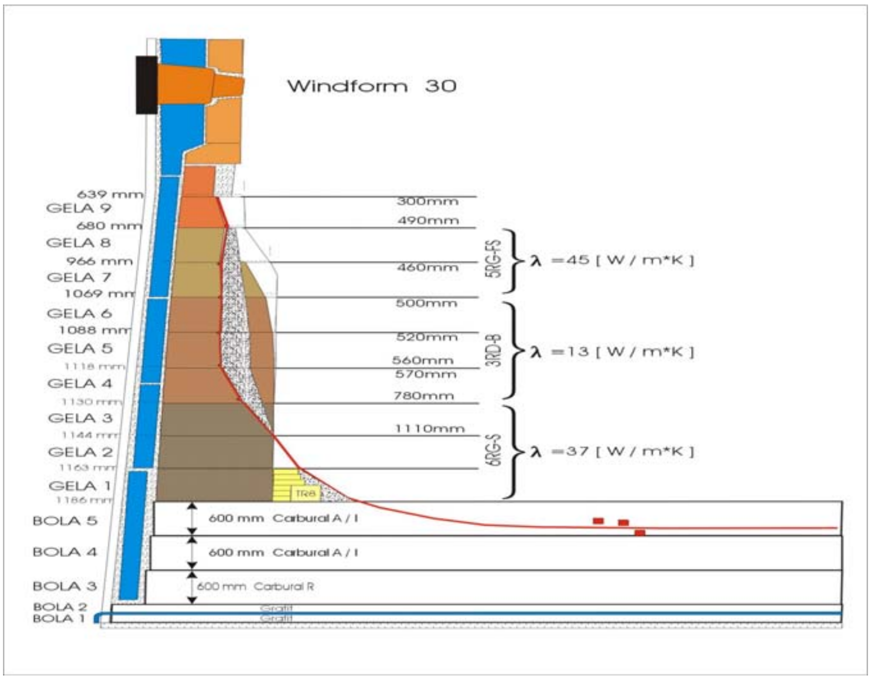

Figure 1. Hearth wall dissection and wear measurement at tuyère No. 30.

Figure 1 shows the use of different carbon block qualities at the interim reline. The different carbon block qualities showed specific results of the wear behavior like the formation of a brittle layer.

ISSN 2176-3135

The reason was the non-availability of sufficient material at the emergency repair. Mainly in the rows GELA 4 to GELA 6 the plain carbon material „3 RD-B“ with low heat conductivity of 13 W/m K showed the formation of a brittle layer.
The use of titanium products was initiated before the interim repair, and after the reset the co-injection of pulverized coal and RUTILIT NF was developed.[3-8]
After the stop, also core drillings were carried out in order to check the wear of the carbon. Titanium residuals were analyzed which formed a protective layer during the co-injection periods.

3 INDIVIDUAL WORK STEPS OF THE RELINE

After the clearing of the hearth from the remaining burden, a thin layer of about 30 cm of solid salamander (260 t) was blasted. The clearing and the blasting lasted about four weeks. Thereafter, the construction of the new components could start. In the following, the individual work steps of the reline are specified.

3.1 Erection of the New Hearth

Taking into account the experiences of the previous campaigns of the Rogesa blast furnaces, a new hearth design with the following items was designed:

- The stave coolers inside the hearth shell were replaced by an outside channel cooling which is integrated into the stave water circuit,
- the slope angle of the shell was lowered in order to obtain a higher refractory thickness at the wall,
- the carbon block quality of the hearth wall was changed into a higher heat conductive super micro porous grade,
- the depth of the sump was increased and a low alumina upper bottom layer was built in, and
- a ceramic cup of nitride bonded high alumina refractory with a thickness of 400 mm was installed.

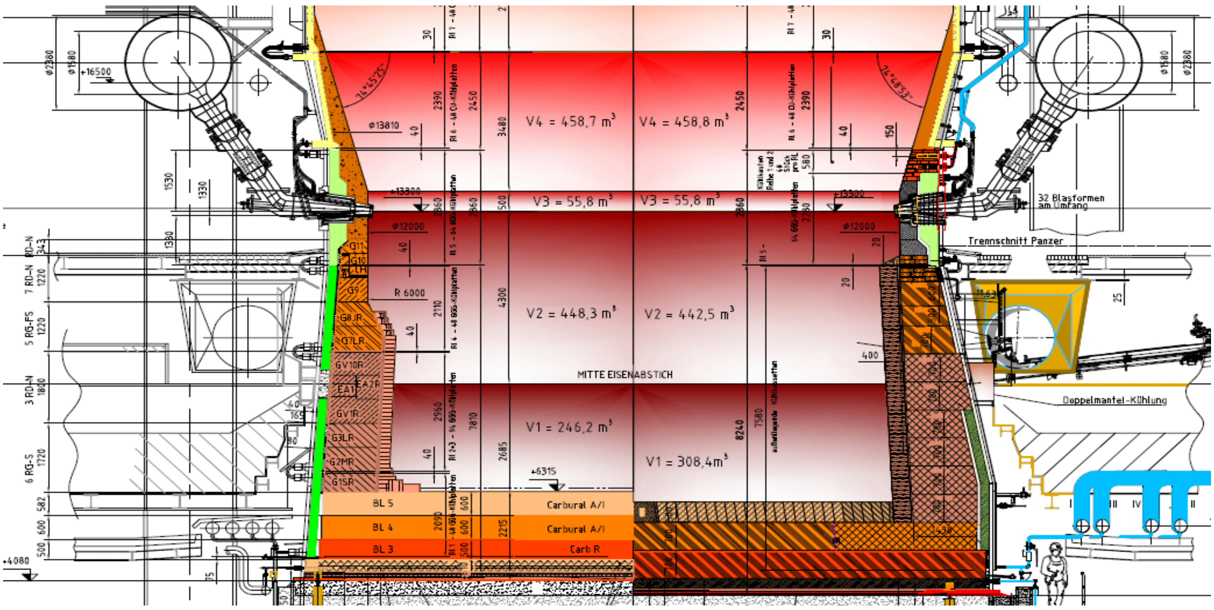

Figure 2. Old and new design of the hearth.

ISSN 2176-3135

Figure 2 shows the comparison of the old (left) and new design (right).
The shell of the new hearth was preassembled outside and ring wise installed after the demolition of the old bottom cooling and shell.

Figure 3. Preassembled shell of the hearth with the shell of the tuyère level thereupon.

Figure 3 shows the preassembled shell of the hearth with the shell of the tuyère level thereupon. The cutouts of the tuyères were made at site after installation.

Figure 4. Displacement of a ring element of the hearth shell on the slide rail.

ISSN 2176-3135

Figure 4. shows the displacement of a ring element of the hearth shell on the slide rail.

3.2 Shell Cooling System

The „weak point“ of the cooling system of the furnace was at the tuyère level where also occurred a breakout in March 2010 which caused a three day stop for repair.
In the future planning for the Rogesa blast furnaces, a high performance operation with also high levels of PCI is scheduled. These conditions consequently require a cooling system, which is capable to resist these higher heat loads.
In order to improve the cooling capacity at that location and of the entire shell, the following improvements were implemented:

- At the cast iron tuyère stave the upper part was replaced by two rows of copper cooling boxes between tuyère level and bosh (Figure 5),
- the copper staves of the belly and the two rows of the lower shaft were removed, overhauled and reassembled because of their good condition,
- one more row of copper staves was mounted at the mid shaft,
- four rows of cast iron stave from mid to upper shaft were renewed,
- two more rows of cast iron staves were mounted in the upper shaft up to the throat armor.

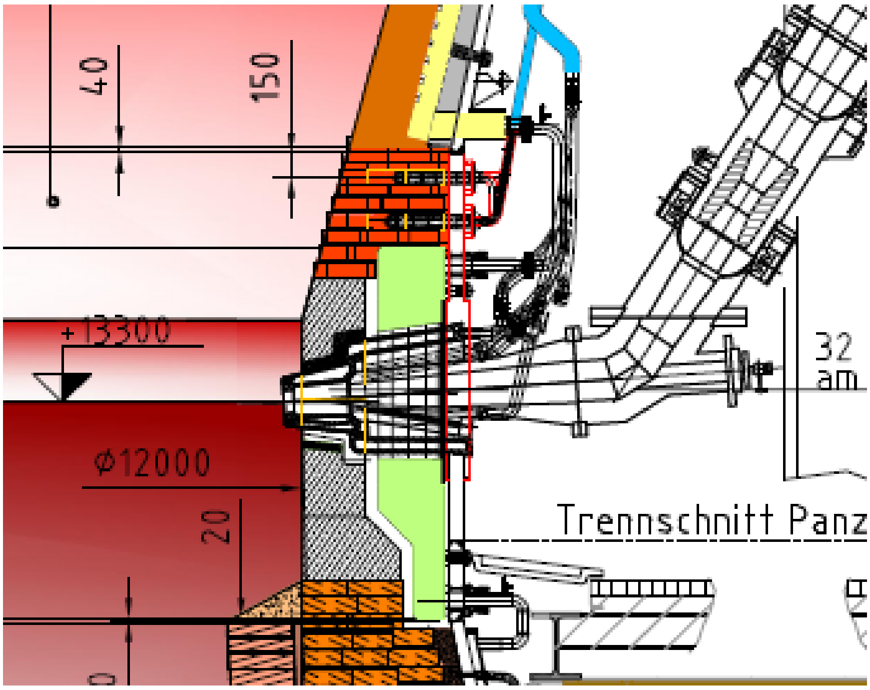

Figure 5. Cooling system at tuyère level and bosh.

3.3 Tuyère Cooling System

The tuyère cooling system was also improved in order to withstand the increased future loads by the high level of PCI with oxycoal lances. The following modifications were performed:

- Construction of a new pipe work of the water supply of the tuyères,
- Use of new designed spiral tuyères with high intensity cooling by increasing of the water pressure to 10 bar g and water flow rates of two

ISSN 2176-3135

times 35 m^3/h for nose and body by the installation of new high pressure pumps, and
- Installation of a water pressure expansion turbine to recover a part of the potential energy.

3.4 Charging System

The burdening system was thoroughly renewed because the existing installation was in service since 1985 and was damaged by corrosion. The hoppers of the bell less top were replaced and enlarged to a capacity of 53 m^3 (85 t burden material and 25 t for coke).
Concerning the gearbox and the rotating chute Paul Wurth installed the prototype of a new developed system (BLT®GEN3 gearbox). The gearbox is designed to support highest thermal loads and to guaranty easy maintainability
The rotating speed of the distribution chute is adjustable up to 12 rpm for high process flexibility. The new geometry of the chute allows achieving:
- an undisturbed material flow, thus avoiding chute overflow or spillage,
- a perfectly bundled material flow,
- an increased falling distance at burden level,
- a homogenous layer deposit.

The chute is design for perfect center coke charging.
Figure 6 shows a picture of the new BLT®GEN3 Gear with distribution chute installed on the Paul Wurth test rig, Fig.7 after installation on BF5 during the reline with the new charging hoppers.

Figure 6. Paul Wurth BLT®GEN3 gearbox and rotating chute at the test rig.

ISSN 2176-3135

Figure 7. Shows the new hoppers and the Paul Wurth BLT®GEN3 gearbox

3.5 Casthouse

At the casthouse, the old machines were in service since 1985. The clay gun and the taphole drilling machine had to be dislocated because of the new geometry of the hearth shell, and they were replaced by new machines, the drill is now equipped with a fully hydraulic driven hammer. The existing dedusting system was overhauled (Figure 8).

Figure 8. Cast house machines.

ISSN 2176-3135

3.6 Hot Blast System

After cooling down of the hot stoves and the hot blast system, the refractory lining of the hot blast main and the bustle main was renewed. The metallic compensators of the mains were replaced because of corrosion. The refractory at the domes of the hot stoves was also refurbished.

3.7 PCI

The capacity of the PC injection system was already enlarged by a third grinder with a capacity of 50 t/h and the erection of a second injection vessel at the first quarter of 2010. By these measures, the possible injection rate was increased to 70 t/h, which represents a specific PCI rate of 230 kg/t HM. After commissioning of the blast furnace, the coaxial lances were also ready for operation.

3.8 Slag Granulation

The slag granulation plant was completely refurbished. A new cooling tower without baffles was erected and the old condensation stack together with the water-collecting basin was replaced.

3.9 Electrics and Visualization

A new 400 Volt electrical current distribution was installed comprising a length of 80 m of new control cabinets for the power supply. The new installed control technique required a total length of about 200 m of new cabinets. About 20 programmable controllers were completely renewed.

4 BLOW-IN OPERATIONS

After 102 days of downtime, the furnace was put on blast on 21st of October 2010. Before this, the hot stoves had been reheated during 26 days and all the tests of the mechanical and electrical equipment were successfully performed. During the filling of the furnace, the trajectories of the new chute of the bell less top were measured.
The blow-in operation proceeded without major problems and the blast volume could be raised progressively (Fig. 10). The consumption of reductants could be decreased stepwise to the scheduled value of 485 kg/t HM. Fig.11 shows the consumption of the reductants. Already after 6 days, the coal injection could be taken in operation and after 15 days a rate of 160 kg/t HM was reached.
A scheduled maintenance stop was made on the fifth day after blowing in.

ISSN 2176-3135

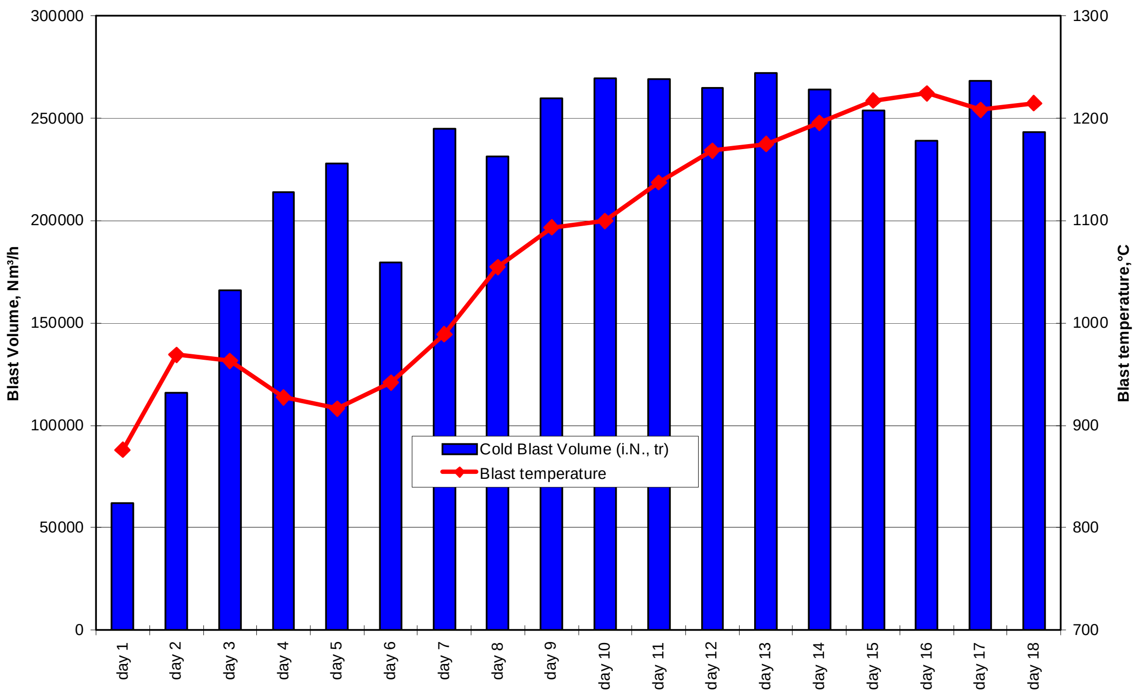

Figure 10. Hot blast volume and hot blast temperature for the first 18 days.

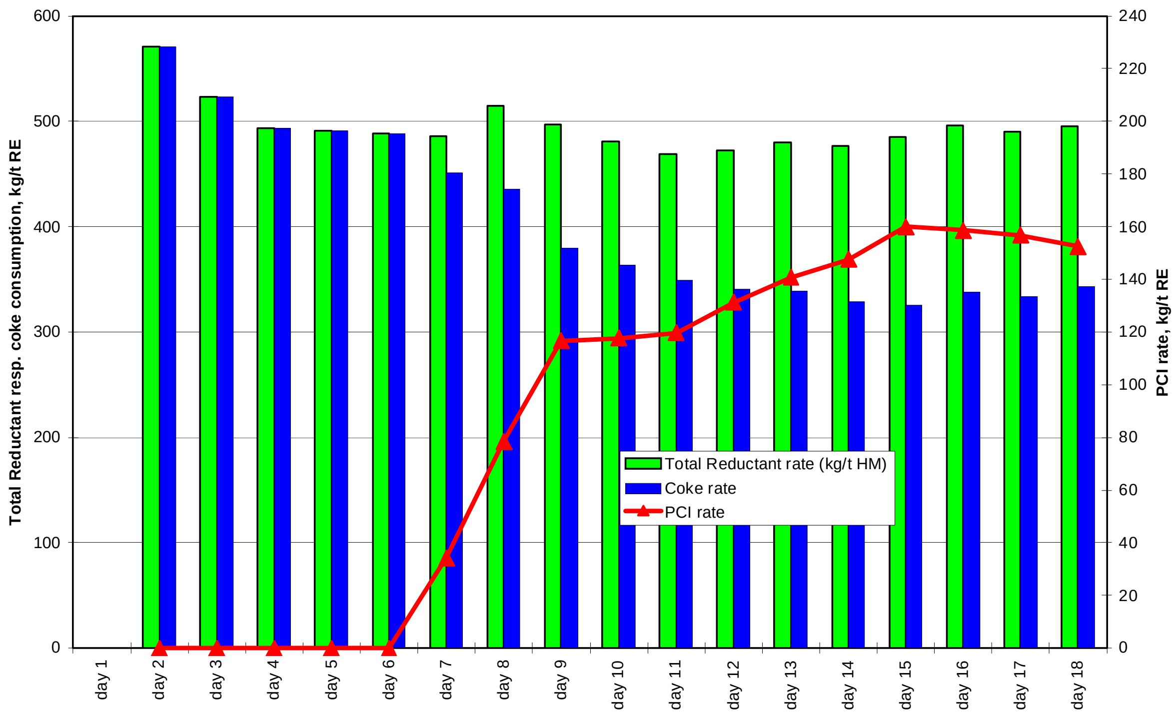

Figure 11. Consumption of reductants.

ISSN 2176-3135

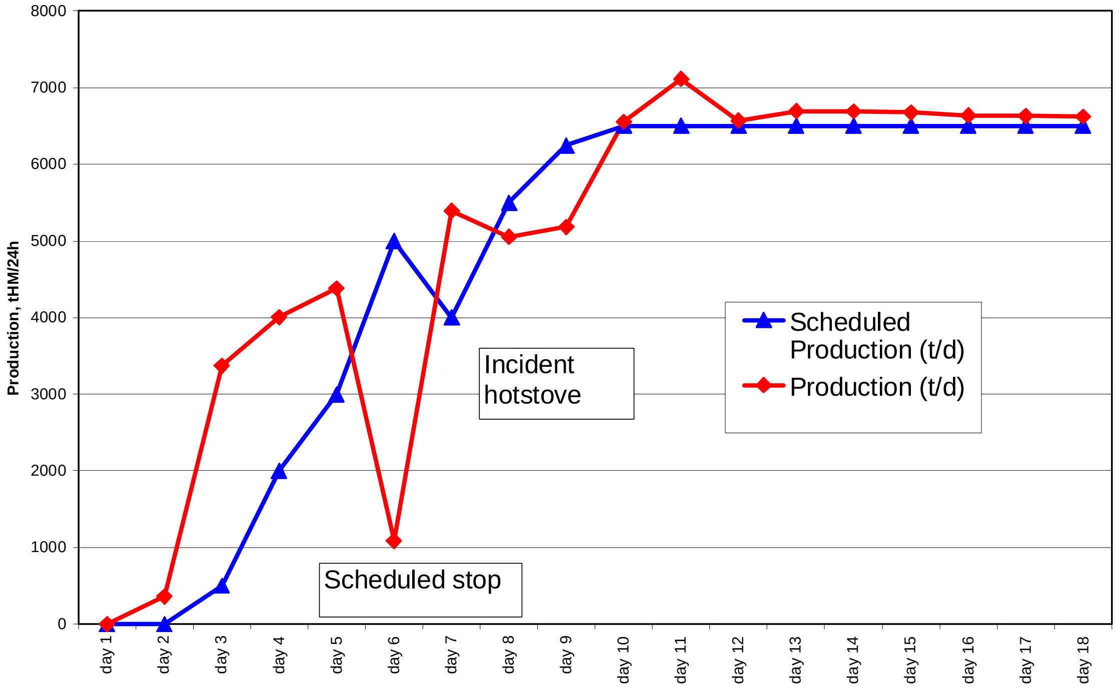

Figure 12. Shows the scheduled and effective hot metal production during the first 18 days

5 CONCLUSIONS

After the second campaign, Blast Furnace No. 5 of ROGESA at the site of Dillinger Hüttenwerke was thoroughly relined during a downtime of 102 days.
The results of the campaign concerning productivity and final wear of the refractory were very satisfying and the chosen point in time for the reline was optimum.
The dissection of the hearth showed the effect of the different carbon quality on the wear. The preparation works like blowing down procedures and tapping of the salamander were successful.
The main work step was the complete rebuilt of a new hearth after the latest technical findings concerning refractory and cooling efficiency. The shell cooling system was also systematically improved by additional cooling boxes, one row of copper staves more and two rows of cast iron staves more. The tuyère cooling system allows now the use of the latest state of the art tuyère construction with highest cooling capacity.
The PW BLT®GEN3 charging system represents now of the most modern BLT system with highest flexibility, optimum cooling, and easy maintainability.
This furnace is operated with a PC injection system, which is able to attain the highest injection values by special oxycoal lances with an optimum equipartition. The commissioning took place as scheduled.
Blast Furnace No. 5 is rebuilt with excellent equipment and installations for a long and successful third campaign.

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