# RESULTS FROM RECENT OXYGEN CONVERTER REVAMPING PROJECTS *

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**Abstract**
Steelmakers are facing challenging times due to production overcapacity, volatile markets and stricter environmental regulations. As a consequence investments are focus in modernization and upgrade of existing capacities these days. Primetals technologies has realized a wide range of revamping and upgrade projects in the recent past; selected projects highlighting the benefits from such upgrades will be shown. At Ruukki, SSAB, Finland three converters have been exchanged and improvements of the metallurgical process like yield and lining lifetime have been achieved . At AM Mittal Temirtau, Kazakhstan a Vaicon Measurement Manipulator was successfully implemented and probe taking and measurement at the converter is running now without any manual operator interference. The last project presented is the replacement of two BOF converters at AM Dabrova Gornica, Poland.
**Keywords:** Converter Revamp; Modernization; Converter Suspension.

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## 1. INTRODUCTION

Steel industry investments are focused on modernization and upgrade of existing capacities due to production overcapacity, volatile markets and environmental regulations. Due to rough operating conditions and the high temperatures in converter steelmaking some wear of the equipment is inevitable. Hence, exchange of the equipment is required from time to time. Such exchange of equipment allows of course to optimize the equipment and the process further instead of simple replacing the equipment by reusing the existing design. Typical examples are optimization of vessel geometry and increase of specific reaction volume; improvement of mechanical design to increase components lifetime, installation or optimization of bottom stirring with respect to flow rates, positioning of stirring elements or installation of slag retention systems.

In the figure below an overview of selected BOF converter revamping's executed by Primetals within the last years is given.

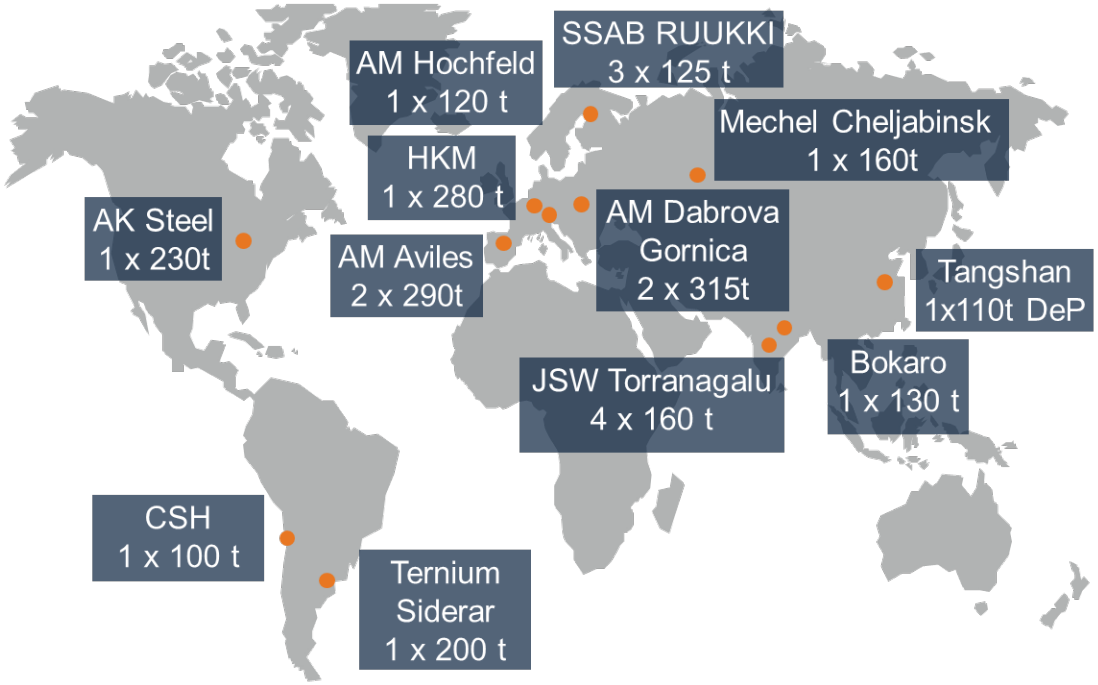


Figure 1: Recent BOF converter revamping projects realized by Primetals Technologies.

In the following some of this projects are presented in detail and benefits from upgrades highlighted. At SSAB EUROPE OY, Finland three converters have been exchanged and improvements of the metallurgical process like yield and lining lifetime have been achieved. At AM Hochfeld, Germany, converter has been replaced and a Measurement Manipulator was successfully implemented and probe taking and measurement at the converter is running now without manual operator interference. The last project presented is the replacement of two BOF converters at AM Dabrova Gornica, Poland, where at the new converters also pneumatic slag retention system – Vaicon Stopper was installed.

## 2. CONVERTER DESIGN

### Suspension System

One common issue for revamping projects is the restricted space available due to the foundation and steel structure that already exists and should be changed only to the lowest extend possible. Furthermore, in most older steel plants tapping weight was increased over the

years and consequently the given design space is relative small compared to the actual heat size. Hence, design solutions for the converter are required that allow to install optimized vessel geometry within the available space. The new Vaicon Link 2.0 converter suspension system was developed exactly for this purpose. It connects the vessel shell with the trunnion ring using eight identical link elements. This ensures ideal support of the vessel on eight points with minimum space requirements. Hence, usage of the Vaicon Link 2.0 converter suspension system allows maximizing the vessel volume and optimizing its shape while prevailing the actual space constraints.

The principle of the links is used successfully now for more than 20 years [2]. The latest improvements of the system are the new design of the link and the usage of eight identical links instead of five links with two different sizes in the earlier version. In respect to old bracket and wedge suspension system the Vaicon link 2.0 has the advantage of free thermal expansion and no maintenance effort for re adjustment of wedges. An overview about the main developments is provided in Figure 2. The link can also be combined with lamella elements – called Vaicon Lamella. Lamellas are used to carry the load in blowing position, two links above the trunnion on each side are used to carry majority of the load during tapping and charging. In respect to the lamella system the Vaicon link system requires no onsite welding resulting in minimum installation time onsite. In total almost 100 references using the link system have been realized so far by Primetals Technologies – see Figure 2 and [2] for details.

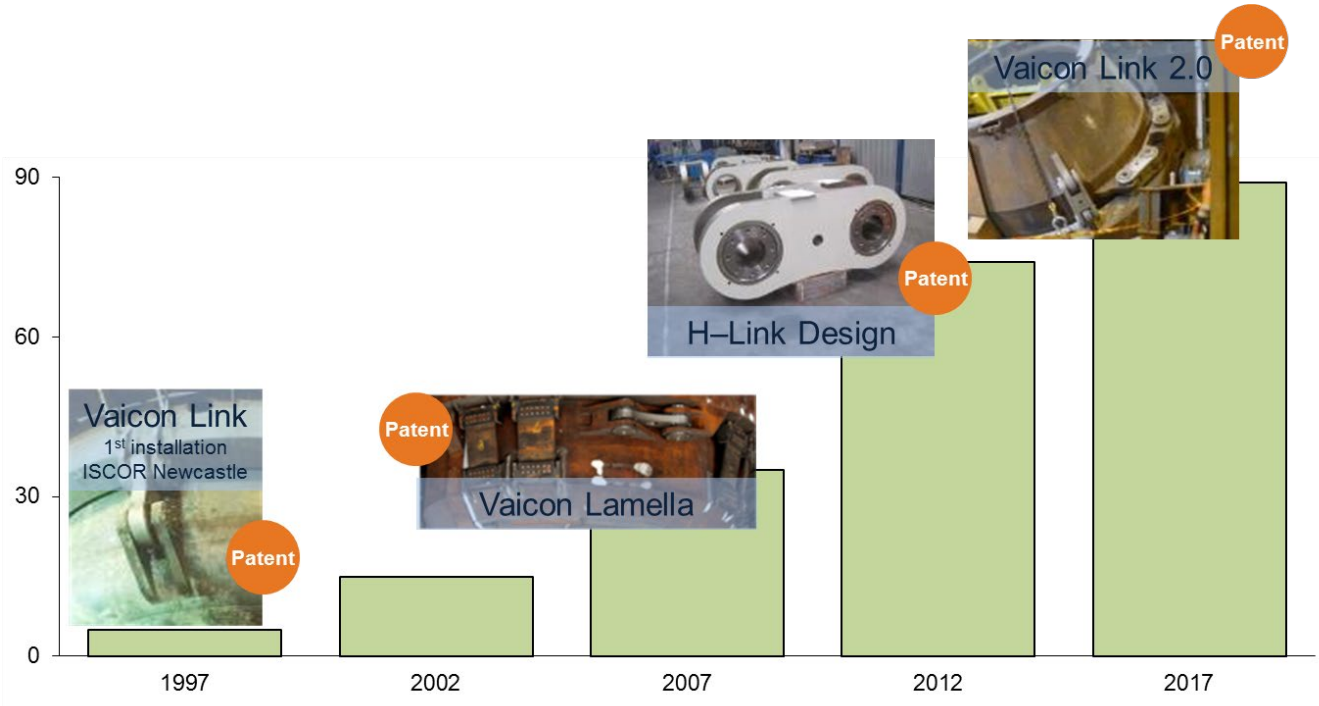


Figure 2: Development of Vaicon Link converter suspension system and references realized.

Another important aspect in converter design is material selection. While the vessel is mainly loaded by thermal loads the trunnion ring is mainly loaded by fatigue loads. Hence for the vessel a creep resistant material is required, while for the trunnion ring materials high in fatigue strength are required. Consequently, creep resistant steels, still easy to weld are recommended for the vessel (e.g. 16Mo3), fine grained structural steels high in fatigue strength (e.g. P355NH) are recommended to be used for the trunnion ring.

## 3. CONVERTER EXCHANGE AT SSAB RAAHE

During the year 2013 SSAB Europe Oy started detailed considerations for the revamping and modernization of its LD converters in its Raahe plant and in beginning of 2014 the contract was awarded to Primetals Technologies. The plant is designed for 3x125 ton converters, operating in a 2 out of 3 mode, resulting in a total annual production of 2.5 mt. The old vessels dated from the year 1986 are replaced by new ones within the project stepwise until August 2016. The new vessels are designed according to the latest state of the art, which allows for various benefits.

The maintenance free and space saving converter suspension system Vaicon Link 2.0 allows increasing the vessel volume without any change of the existing converter foundation. The suspension system ensures free thermal deformation of the vessel and highest lifetime of the converters. Pictures of the installation of the suspension system are shown in Figure 3.

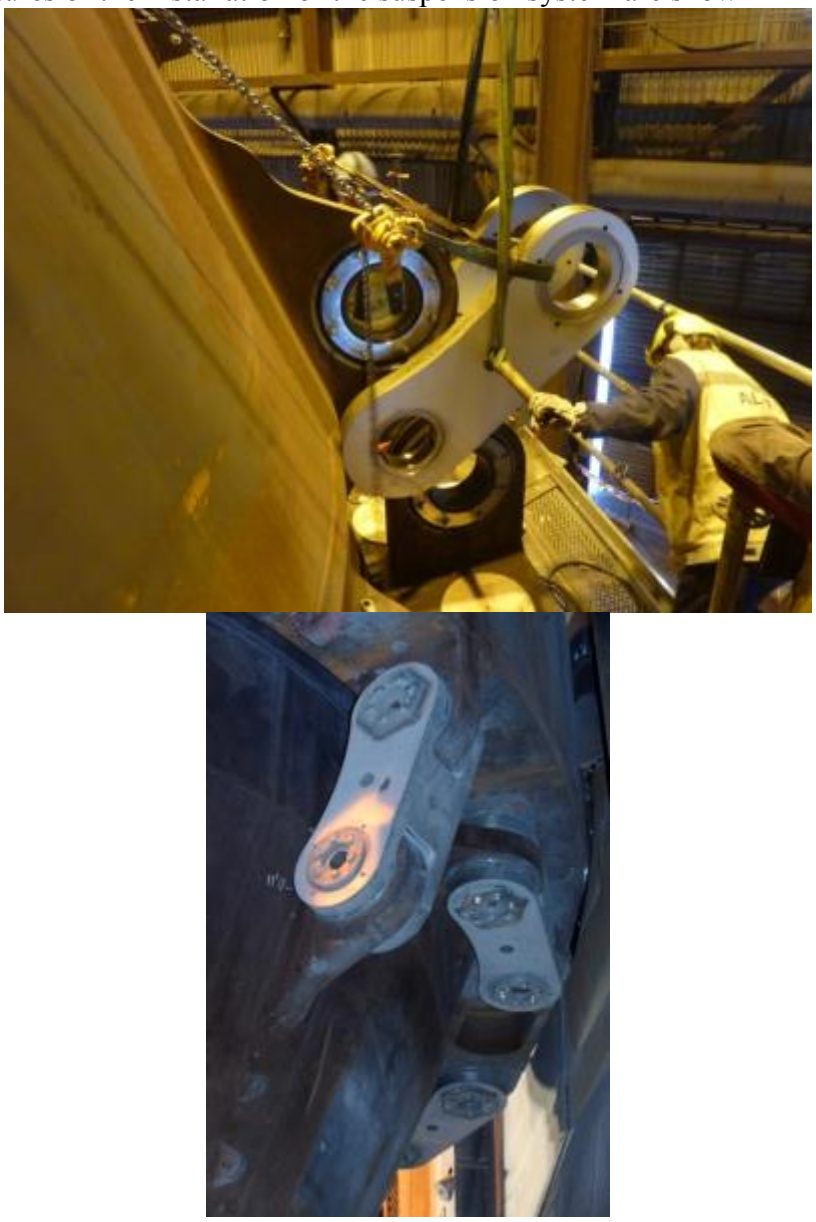

Figure 3: Installation of Vaicon Link 2.0 converter suspension system at SSAB, Raahe. Installation of vertical link (left); completely installed suspension (right).

The increase in vessel size yields a high specific reaction volume of 0,9m³/t which together with a new designed lance tip and an improved and optimized bottom blowing system with a specific stirring rate of 0.1 Nm³/t/min is aiming for better metallurgical results, such as yield

improvement of 1%, total content of FeOx in the slag below 13.7%, reduced blowing duration as wells as reduced tendency for slopping. These results are shown together with results from two other revamping projects in Table 1. Comparison of the values shows that for all projects optimization of the vessel geometry was done and an increase of the specific reaction volume was achieved. This together with some process optimization leads to an improvement of the metallic yield and the steel properties (e.g. [C] x a[O]) at the end of process.

Table 1: Improvements achieved in converter revamping projects[1, 3].

| | | Old vessel | New vessel | Delta |
|---|---|---|---|---|
| SSAB Raahe 3x120t | Tapping weight | 125 t | 125 t | - |
| | Specific reaction volume | 0.70 m³/t | 0.90 m³/t | + 0.20 m³/t |
| | [C] x a[O] | 27.4 | 22.98 | - 4.42 |
| | FeO in slag | 16.2 % | 13.7 % | -2.5% |
| | Metallic yield | 90.0 % | 90.3 % | + 0.3% |
| voestalpine, Linz 3x180t | Tapping weight | 159 t | 177 t | + 18 t |
| | Specific reaction volume | 0,62$m^3/t$ | 0,73$m^3/t$ | + 0,11$m^3/t$ |
| | [C] x a[O] | 21,4 | 16,5 | -4,9 |
| | FeO in slag | 21,70% | 17,50% | -4,20% |
| | Metallic yield | 90,53% | 91,57% | + 1,04% |
| JSW 4x160t | Tapping weight | 172 t | 180 t | + 8t |
| | Specific reaction volume | 0,72 m³/t | 0,85 m³/t | + 0,13 m³/t |
| | O2 at blow end | 670 ppm | 580 ppm | -90 ppm |
| | Tap-to-Tap time | 60min | 53min | -7min |

In addition a new relining concept is applied to increased converter lining lifetime. The existing slag stoppers are reused and ensure minimum slag carry over during tapping. The new vessel together with the slag stopper installed after charging of the first heat in shown in Figure 4.

Due to the prevailing site restrictions as regards to time schedule, available space, existing facilities and ongoing steel production, the project was challenging for both companies involved.

Figure 4 : LD (BOF) converter supplied by Primetals Technologies at the Finnish Raahe works of SSAB Europe Oy.

## 4. CONVERTER EXCHANGE AT AM HOCHFELD

Mid 2016 AM Hochfeld, Germany awarded Primetals Technologies with the replacement of BOF converter #2 at its steel plant in Duisburg. The converter has a tapping weight of 150t and was at the end of its lifetime. The scope of the project covers fully engineering as well as supply of converter vessel shell, Vaicon Link 2.0 suspension system, trunnion ring, new dog house doors and new suction boxes for the secondary dedusting system. In addition a manipulator for measuring and sample tacking from the steel bath at the tilted converter was installed. The converter main bearings as well as the tilting drive have been refurbished and reused.

The project included also the erection of the equipment supplied; this was done by a consortium led by Primetals Technologies in Partnership with Buchinger Anlagen-Stahl-Rohrbau GmbH, Austria.

The measuring manipulator is mounted on the left converter dog house door and moving with the door when it opens. In parking position the manipulator is tilted towards the doghouse and parking in parallel to it. As a result it requires minimum space and leaves the full platform free for operations and material manipulation e.g. by forklift. This parking position ensures further that the manipulator is not damaged by the crane during charging. Before measurement is started the manipulator is tilted by 90° to working position and a probe is attached to the measuring lance by the operator. The dog house doors are opened a bit to form a gap between them and through this gap the measuring lance is entering the converter and a

measurement is done – see Figure 5. Type of measurement depends on the probe attached – in principle temperature, carbon content, oxygen activity can be measured as well as samples from steel bath can be taken. After the measurement the used probe is removed again by the operator and the sample is unpacked if one was taken. The lance for measurements is cooled by air only. Due to the short time required for measurement such simple cooling solution is sufficient and still lifetime of the lance is high.

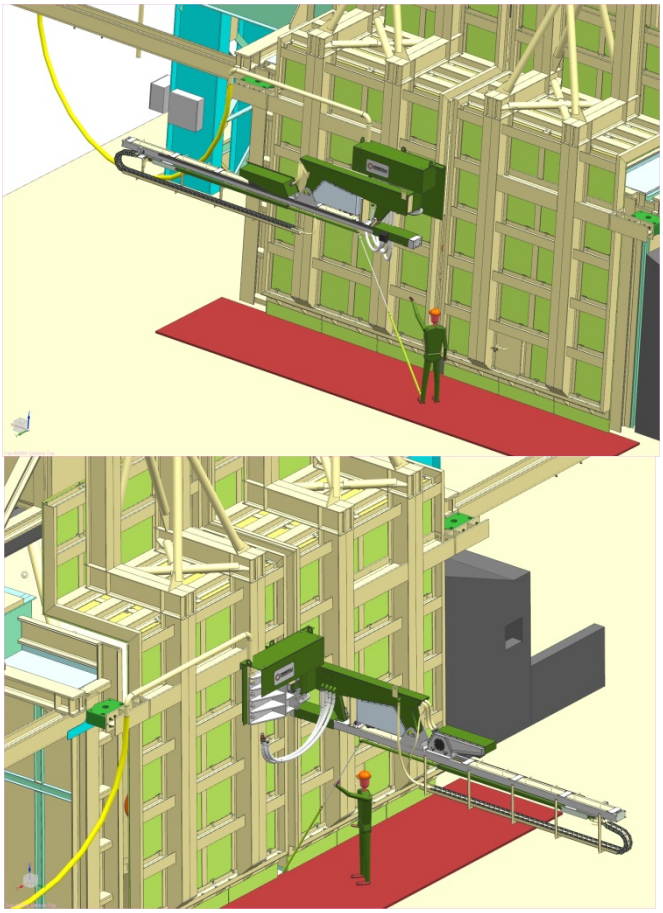

Figure 5: Measuring manipulator in stand by position (left) and working position (right)

The measuring manipulator allows fast and 100% optimized and repeatable measurement completely independent of any human influence. This ensures high quality and reliable measurements within 20 seconds for a normal, single measurement. The operator needs only to handle the probes and is not required to operate in front of the hot converter mouth with some manual measurement lance. This improves the safety situation for the operator considerably.

The first measuring manipulator was started up in 2010 at AM Eisenhüttenstadt, Germany and is in successful operation since then. In the meantime several further installations have been realized with applications on the charging side as well as on the tapping side for direct measurements during tapping. In total nine manipulators have been sold yet and most of them are already in operation.

In the photograph in Figure 6 the new converter during charging of the first heat is shown. On the right hand side the new dog house doors supplied can be seen. On the left hand side the measuring manipulator in stand by position can be seen.

Figure 6: LD (BOF) converter supplied by Primetals Technologies at the Hochfeld works of AM.

## 5. CONVERTER EXCHANGE AND INSTALLATION OF VAICON STOPPER AT AM DABROVA GORNICA

The last project to be presented is the exchange of two 315t BOF converters at AM Dabrova Gornica.

While a European competitor was awarded with replacement of the first converter at AM Dabrova Gornica in 2013, the replacement of the second and the third converter was awarded to Primetals Technologies and the last one went now in operation in January 2018. The scope of the projects covers engineering and supply of converter vessel, trunnion ring, Vaicon Link 2.0 converter suspension, main bearings and slag shields. In addition to the renewing of the converter a slag retention system was installed – see figure Figure 7 for a picture of the new converter after charging of the first heat.

AM Dabrova Gornica decided to use proven Vaicon stopper technology which allows sealing the tap hole at the end of tapping contactless by a jet of nitrogen blown into the tap hole from a moveable arm. End of tapping is predicted by a camera system monitoring the tapping stream. By the different infrared radiation of steel and slag beginning of slag tapping at the end of tapping can be detected. This is used as signal to actuate the slag stopper and stop the tapping stream. This way the amount of slag carried over to the ladle can be reduced to values as low as 2-3kg of slag per ton of steel tapped.

The order also includes removal of the existing converter and assembly and installation of the new equipment. This was handled in a consortium with our partner ZKS Ferrum S.A., Poland.


Figure 7: 315t LD (BOF) converter supplied by Primetals Technologies at AM Dabrova Gornica.

## 6. CONCLUSIONS

Primetals Technologies has realized several converter revamping projects in the last years. The scope of the projects range from pure exchange of worn and outdated equipment to full modernization projects with optimization of vessel geometry and process as well as installation of new equipment for improvement of operator safety and steel quality. Examples for the latter are installation of measuring manipulator for automated measurement at the tilted converter as well as installation of Vaicon stopper for reduction of slag carry over to the ladle during tapping.

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