Gunning robots improve repairs

The hot gunning repair of aggregates – converter, ladle, EAF, RH-snorkels and so on – is a cost-saving alternative to shutting down and renewing the complete lining. It also increases the service life of a furnace, leading to savings of reheating energy. Quick repair also reduces the number of circulating aggregates, says **Christian Wolf***

THE use of gunning manipulators is necessary to improve working conditions for the operators. They further allow for a more well-directed repair of the corresponding positions. When compared with manual gunning, higher gunning capacities considerably reduce repair time and heat loss of the aggregates. In short, the steel plant saves money on refractory and has less downtime. Moreover, there is a reduced risk of accident. In the melt shops, however, gunning robots have to be customised for optimum performance.

Ladles

A typical refractory consumption for ladles is 0.2kg/tonne of steel at the bottom and side wall and 0.4 kg/tonne of steel in the slag zone. When checking the lining it is often found that only the slag zone needs to be repaired. At plants with secondary metallurgy the slag zone wears out quicker. Sometimes the top of the lining (the lip ring) is damaged because slag removal using a break-out machine has been too forceful.

The ladle can be put back into operation very quickly after gunning repair of the slag zone alone has been carried out. There is no need for replacing refractory, which is still good to go, and there is no loss of time or energy to heat up and dry a new lining.

The most convenient location for a hot repair is the tilting stand where the slide gate is repaired. It is possible to use a manual gunning lance, but this can be physically stressful in hot working areas (**Fig. 1**).

When using a gunning robot the gunning repair is:-

- quicker, because of higher gunning rates
- more efficient, because of the well-directed jet
- easier, because of no physical stress for the worker

Depending on plant layout Velco has developed two different solutions for this task. Version one is a fixed installation consisting of a rotating lance that can move in and out and runs on a beam structure. The robot shown has been in operation at a German steel shop since 1987. For each repair stand one robot is required. (**Fig. 2** and **Fig. 3**).

Version two is a gunning lance, which is mounted on an electric trolley that can drive from its parking position to one or more repair locations. **Fig. 4** shows a manipulator for the repair of laying ladles (liquid content approximately 150 tonnes) at Voestalpine Stahl in Linz, Austria. The manipulator is driven in front of the laying ladle and is operated by a radio remote control. The robot is fed by a pressure vessel gunning machine with a high pressure water pump and an electronic water adjustment.

At Outokumpu in Tornio, Finland, Velco has installed a fully automatic gunning system for standing ladles located in a specially erected hall. The ladles are transported via rail into the gunning hall. In total four gunning positions and different programs for automatic gunning of bottom, sidewall and spout are available. The programs can be started individually or sequentially without interrupting the gunning process. Two different gunning materials are used: a material for the repair of the permanent lining and a light material for the wearing layer. The operator selects the gunning position, the gunning program and the type of material and then the gunning process is carried out automatically.

When changing the gunning material, it is not necessary to exchange the gunning equipment. Furthermore, the operator can take over the manual gunning control using a joystick and can gun individually at

Fig 1: Manual gunning of ladle

Fig 2: Stationary ladle gunning installation

* Managing director, Velco GmbH, Velbert, Germany. Email: cwolf@velco.de


Fig 3: Gunning of slag zone

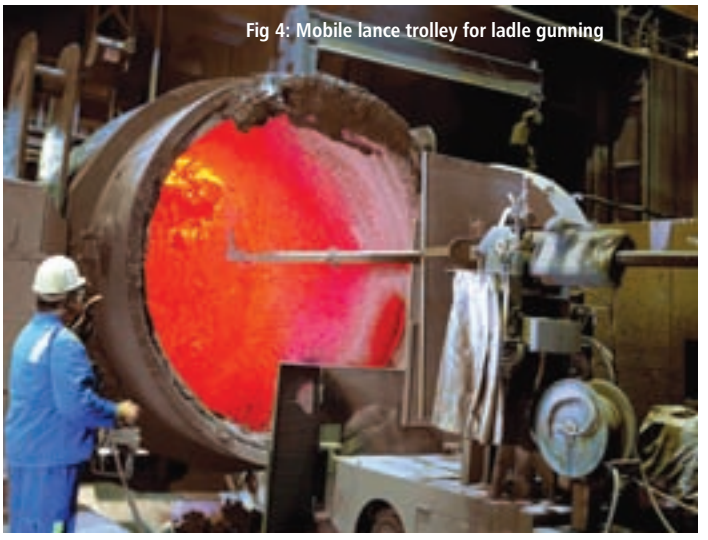
Fig 4: Mobile lance trolley for ladle gunning

selected spots.

This installation considerably reduces working strain and dust exposure for the operator. The necessary gunning time could be reduced, as the gunning robot works at a higher gunning capacity and enables faster change between the two different materials. **Fig 5** and **Fig. 6**

Electric arc furnaces

In the past 25 years Velco has supplied 15 gunning robots for EAF operations. However, due to the different melt shop layouts, no robot is alike. Moreover, the operating principles of the plants are different. A few have the ability to exchange the complete furnace vessel. These plants do minor hot gunning and replace the complete lining every two weeks. Because most plants have to keep the lower vessel in place, the exchange of the lining increases down time dramatically. Hot gunning keeps the furnace running.

Typically, when using hand lancing, a 6m to 8m long pipe is introduced through the slag door. The gunning rate is only 60 to 80 kg/min. Handling the pipe is hard work and not all areas at the furnace are accessible.

Fig. 7 shows the gunning manipulator HYTOP at Deutsche Edelstahlwerke, a stainless steel plant in Siegen, Germany, for the repair of a 140 tonne EAF. When the gunning nozzle is driven into the requested working position, the furnace cover has to be turned away in order to create an entry point. Gunned zones are the slag line, the tapping spout and the door area (**Fig.8**). The robot is fed by three gunning machines, which can run three different material grades. The operator starts the gunning machine and controls the repair by means of joysticks using a radio remote control. Alternatively pre-set gunning programs can be run where the operator pre-selects positions via a touch panel (**Fig.9**) and the robot automatically repairs the selected locations.


Fig 5: Ladle gunning robot

In Germany at BSW in Kehl, the melt shop layout was so tight that no place could be found to locate a gunning robot adjacent to the furnace. The plant operates two independent furnaces, each 100 tonnes, within a distance of only 50m. Here the task was to build a robot that could be used for both furnaces. The robot, known as PNEUTOP, is moved via overhead crane into the furnace and is parked in a support frame located between both furnaces. The robot is fed by a pressure vessel gunning machine (**Fig.10**) and both are controlled by one radio remote control.

The robot is well balanced; the gunning head is nearly as stable as the fixed arm design. When co-ordinated properly the crane movement of the robot does not influence the charging of the other furnace. BSW typically guns two to three tonnes of refractory per repair. Using a higher gunning rate of 125-150 kg/min, the downtime could be reduced compared to hand lancing (**Fig. 11**).

A stainless steel producer in Italy has two 110-tonne EAFs on the same meltshop


Fig. 6: Automatic ladle gunning

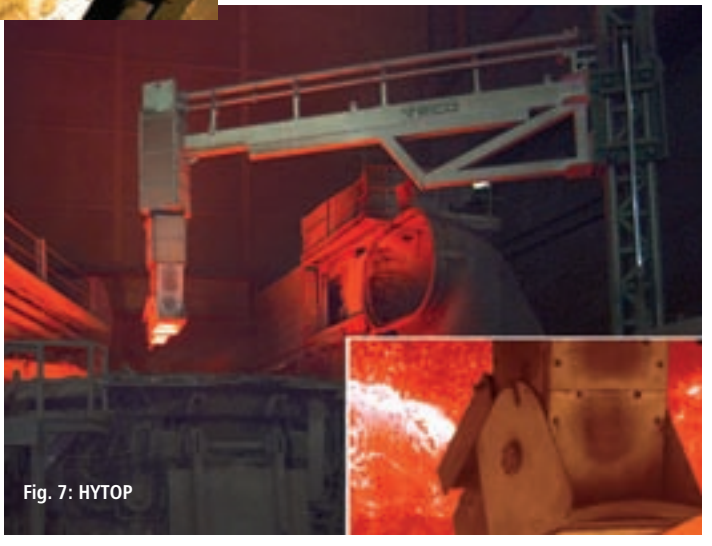
Fig. 7: HYTOP


Fig 8: Slag door gunning repair

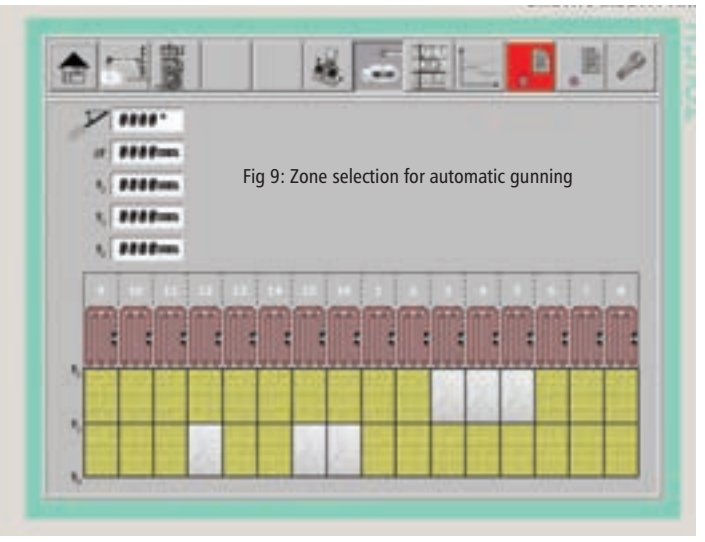
Fig 9: Zone selection for automatic gunning


Fig 10: PNEUTOP and gunning machine

floor and requested a mobile gunning robot mounted on a self-driven carriage. Velco decided to modify a commercial diesel-driven telescopic loader.

The MobiGUN parks on the meltshop deck and can access both furnaces. The gunning head is attached to the boom and is air-cooled by an onboard compressor. For driving, the boom is retracted and the gunning head folded in. For gunning, the boom is expanded and the gunning head lowered from the top to the furnace. All movements of the gunning lance, the water regulation and the start/stop of the gunning machine can be activated with a single radio remote control (**Fig. 12).**

The MobiGUN needs only two connections: one to the gunning material hose and a second to the works water line.

RH-degassers

The high quality requirements of the automotive industry increase demand for vacuum degassed melts. Snorkel lifetime, therefore, is an important factor if the RH-degasser is to be used extensively. Due to the reaction with steel and slag the snorkel wears out internally and externally and the outside lining is often damaged by slag removal using scrapers or de-bricking machines. Keeping the system safe in order to avoid break-outs of hot metal is of primary importance. However, service time is limited as the steel plant's sequences take priority. An unplanned exchange of snorkels should be avoided.

Outside gunning is commonplace, but the workplace is exposed to heat and the operator likes to stay away from the snorkel, so gunning is not always well directed and has high rebound losses (**Fig.13**).

Some steel plants have a service car with an attached platform for hand gunning. Nevertheless, inside gunning is not possible because of the danger of hot steel or slag dripping from the RH-vessel.

Where outside repair is concerned, using a gunning robot is beneficial because the gunning is better directed and the physical stress on workers is reduced (**Fig. 14**). A robot is essential for the inside repair of the RH snorkel (**Fig. 15)**. If gunning is performed well, the consumption is in the range of 0.5kg/tonne steel. Typically gunning takes place after six to eight treatments.

For inspection and documentation of the wear pattern it is possible to attach a camera to the robot (**Fig.16).** Instead of the gunning lance, a water-cooled camera is driven into the snorkel. A video can be made of the snorkel or the lower vessel area. Using the robot's positioning encoders the area in the video can be exactly determined (**Fig.17**). The video can be stored and the wear can


Fig 11: Crane moved robot PNEUTOP


Fig 12: MobiGUN on meltshop deck


Fig 13: High material loss at manual gunning

be documented to determine optimum lifetime. The inspected areas can be precisely repaired with the robot.

Typical robots have a lance for inside repair and a rotating base to reach the second snorkel. When inside and outside repair is requested, most robots have two gunning lances based on a frame that can rotate 180 degrees (**Fig 18**). One lance can repair the inside of snorkel A while the other is doing the outside repair of snorkel B. When finished, the main base rotates, so snorkel A is repaired on the outside and B on the inside.

If the snorkels are placed in the moving direction of the service car, it is possible to simplify the robot design by moving the service car to reach the other snorkel. This requires precise positioning of the service car – which is not always installed. ■


Fig 14: Outside gunning of RH snorkel


Fig 15: Inside gunning of RH snorkel


Fig 16: Water cooled inspection camera

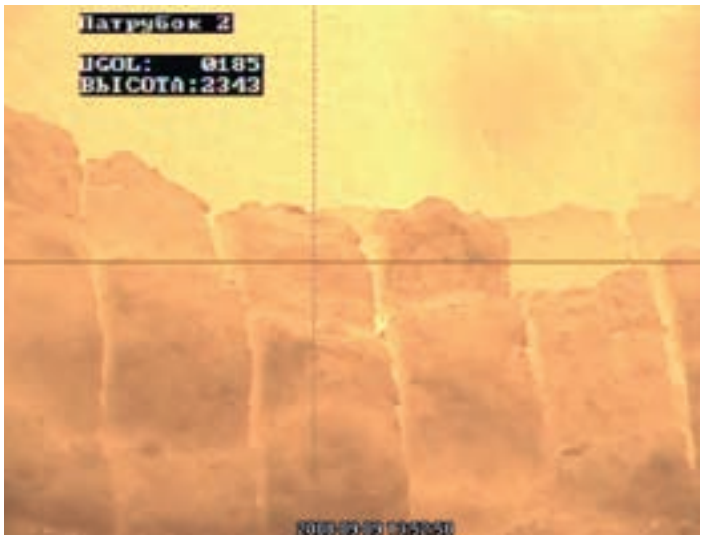

Fig 17 (left): Inside picture of RH-snorkel taken with inspection camera


Fig 18: Gunning robot with two lances for inside and outside repair