Bottom Purging Improvement of Steel Ladle at LD#3 (TSL JSR)

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Background:

This paper describes the journey for improvement of porous plug performance at LD#3 TSCR. Porous Plug material complete characterization ,postmortem analysis, Trial of new design porous plug, Improvement in physical observation of purging through camera, improvement in safety Pad Inspection, Improvement in argon gas line connectivity, Auto coupler & mechanical leakages, Purging Plug maintenance improvement (Usage of PFD), Purging Programmer improvement, Ladle Logistic Improvement all these various studies & initiatives were taken to improve purging performance at LD#3. **Currently the full bottom purging efficiency at LD#3 is 97%, further work is ongoing to achieve 99% full bottom purging efficiency.**

Advantage of Bottom Purging :

With the rapid development of steel industry, the focus is on making more & cleaner steel. Because of this bottom gas stirring is an important aspect in secondary steel making.

(1) Removal of the inclusion by floating them out in the slag i.e., steel cleanliness

(2) Uniform distribution of temperature throughout the bath

(3) Homogenization of liquid steel (alloys & deoxidizing agents are added in presence of purging) .

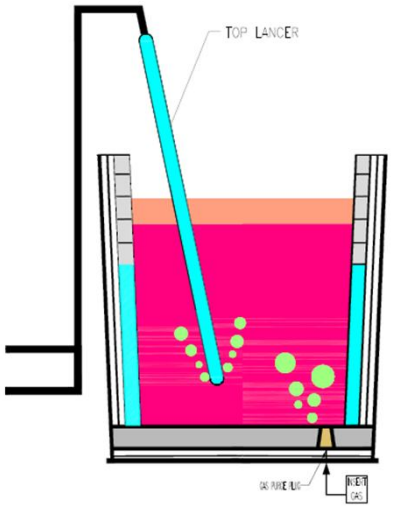


Fig 1: Schematic diagram of ladle with purging arrangements

The LF(ladle Furnace) comes with top lance and one or more Porous Plug at ladle bottom

Type of Porous Plug :

Different type of Porous plug is available in the market like Random, Slot, Segment, Hybrid etc.

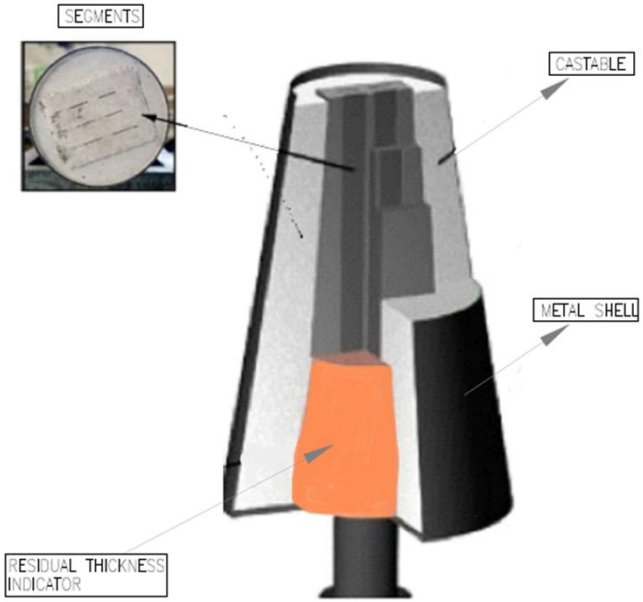


Fig 2: Schematic diagram of segmented porous plug

Bottom purging is most desirable method of gas purging & top lance is used in case of non-opening of Bottom purging . However, effective purging depends on the following ...

- Design & quality of Porous plug material
- Operational parameter & practice
- Maintenance of Purging system

Study was conducted to find out the cause of porous plug non opening at our LD#3 shop & increase the opening rate of plug

Analysis of Non-Purging cases at LD#3 & Initiatives taken over the years to Improve Purging Performance:

Purging performance depends on various factors, non-effective bottom purging is reflected in the increasing use of top lance. Data of Use of Top Lance was studied over the years, the Top Lance data from FY'16 to FY'21 (May'20) is given below in Fig 3

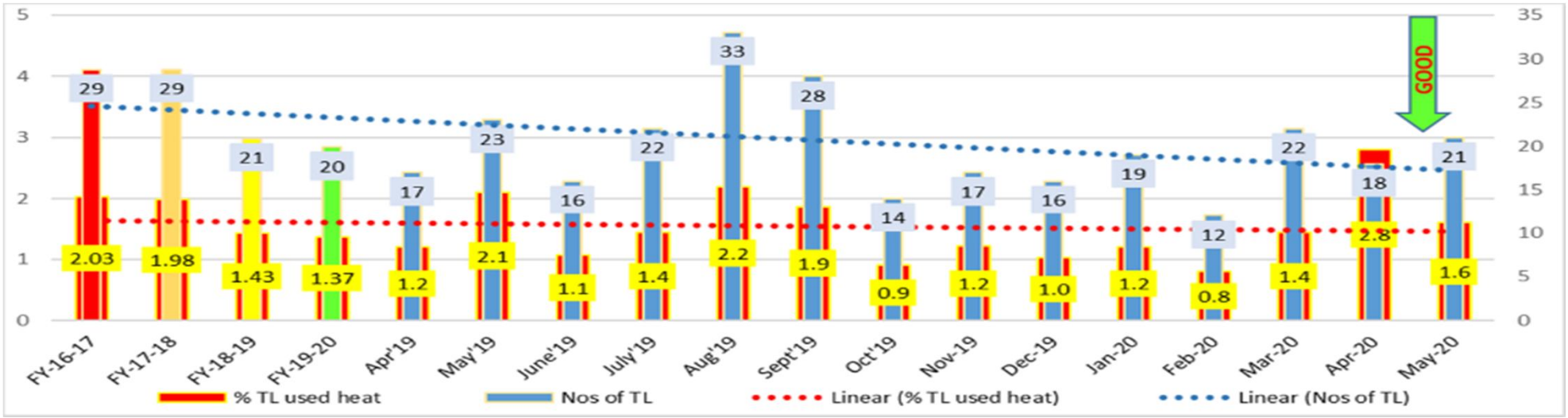


Fig 3: Top Lance consumption data at LD#3-TSL JSR

a) Physical inspection of plug opening:
Physical observation of purging opening is one of the ways to see purging performance. Live camera was installed & access is given to LF control room for inspection eye opening of bottom purging.

b) Argon Gas connection – Auto coupler & NRV valve related issue

Proper periodic maintenance/inspection of auto coupler system & finding of leakages is required before taking ladle in LF Operation.
Improper functioning of NRV valve may lead to block the PP. To suppress this issue regular check-up/maintenance of NRV valve is required. With this maintenance practice non opening of Porus plug is reduced drastically.

c) Quality of segments & castable:
Fusion of segment may occur in presence of low melting phases. To counter measure this, we check the chemical analysis as well as PCE. Following table 1 is a representative analysis report of the segment part.

Table 1: Typical Chemical analysis of segment part

SEGMENT PART				
		$\%Al_2O_3$	$\% Cr_2O_3$	$\%ZrO_2$
New PP		90.10	4.50	4.78
Steel ladle No-13	Used PP-1	89.65	4.10	4.5
Steel ladle No-15	Used PP-2	89.74	4.01	4.27

Table 2: Typical Chemical analysis of castable part

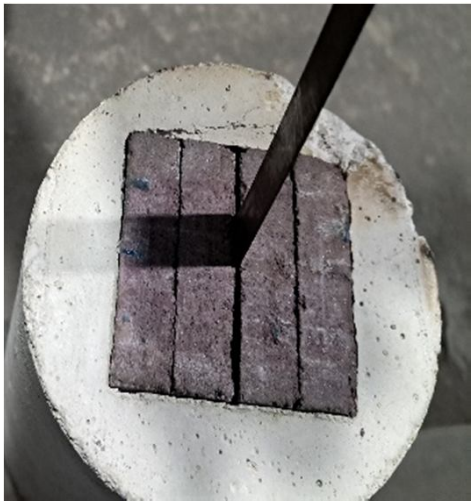
SURROUNDING CASTABLE			
		%MgO	$\%Al_2O_3$
New PP		1.32	95.69
Steel ladle No-13	Used PP-1	1.21	94.95
Steel ladle No-15	Used PP-2	1.16	94.53

d) Remnant thickness of plug

We have investigated the erosion pattern of few used plugs after certain lifetime & found safe remnant length in most of the cases as shown in Fig 4. Metal penetration was also measured at the same time

e) Gaps in between Segments:

Segment gap beyond specified norms may lead steel infiltration in between segment slits. Gaps may also occur due to various phase changes of refractory at higher temperature which may lead to shrinkage.



f) Porous Plug maintenance practice:

After casting ladle is sent to the tilter for various maintenance activity like Plug cleaning. During plug cleaning oxygen lancing is done from front and at the same time nitrogen pressure is given from back to ensure no choking in segment during lancing. The back-line pressure should always be on the higher side than front side gas pressure during cleaning

g) Other operational parameters

Performance of bottom purging is also governed by the following operational parameters ….

- Ladle turnaround time should be as minimum as possible. Ladle should be hot during tapping. Purging should be started just before tapping.
- Tap temperature to be optimum
- Alloys & other charge material should not be charged on empty ladle – should be charged after ¼ of the ladle is filled with hot metal.
- For high holding time ladle purging to be maintained in open condition. If not, hard soft bubbling can be done.
- After the end of heat gas flow should not be stopped immediately.

Conclusion:

As the metallurgical demands in secondary steelmaking increase so do the requirements for safe, efficient gas stirring plugs. As we have seen that efficient bottom purging is not only dependent on good quality & suitable type of porous plug but also plug maintenances practice, operational practice. Purging performance improvement is an ongoing journey at our LD#3 plant with all the cross functional teams to achieve the desired level of performance. Many new initiatives have been taken over the years and many more new trials & initiatives are continuing to reach the goal.

Thank You