Experience with Cold Start Low Carbon Liner SES for Continuous Casting

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Main points

- ✓ General features of SES
- ✓ Reasons and effects of clogging
- ✓ Refractory solutions to minimize clogging
- ✓ Need for Carbon free Liner
- ✓ Case Studies
- ✓ Conclusion

Sub Entry Shroud

❖ **Objective**

✓ Protect molten metal from ambient oxygen during the casting operations.

✓ Maintain a flow distribution in the mold assuring a good steel solidification, with minimum turbulence in the mold.

❖ **Refractory Material**

➢ BODY : Al_2O_3- Graphite, Standard performance.

➢ SEAT: Al_2O_3-Graphite/MgO-Graphite, good erosion resistance caused by the steel flow between the stopper nose and the seat.

➢ SLAG LINE: ZrO-Graphite, good erosion resistance cause by the mold powder.

➢ **Usage Conditions:**

➢ Preheating temperature

➢ Easy Scheduled change possible **(Clogging)**

Different issues with SES

- **Erosion at seat**

  Continuous change in steel flow due to stopper operation.

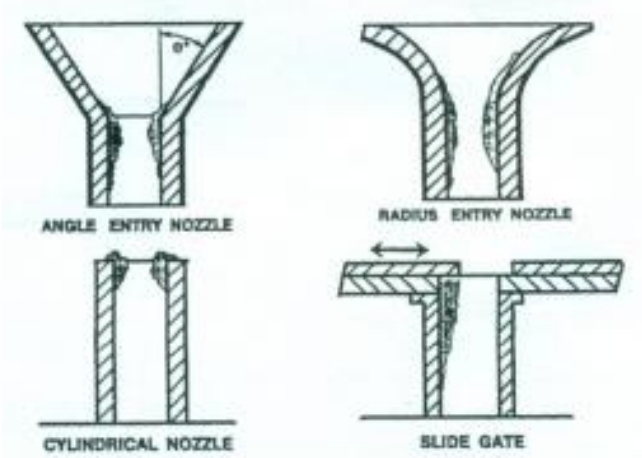
- **Alumina build-up in the barrel**

  i) At some regions of nozzle the steel flow is stagnant allowing inclusions in Al_2O_3 killed steel to adhere the refractory wall.

  ii) Choking due to metal freezing.

  iii) Alumina build-up around the exit-port .

- **Slag erosion:** Chemically reactive Mold powder.



Clogging due to irregular flow of hot metal across various regions

Reasons of Clogging

- ✓ Rate of flow of metal is unsteady along different zones of refractory surface.
- ✓ The presence of C and SiO_2 in refractory surface facilitates formation of alumina deposits.
- ✓ Creation of CO at elevated temperature from carbon reacts with aluminum dissolved in the molten steel to form alumina at the refractory wall.

Clogging Parameters

Steel Grade

Anti-Clogging Material on the inner surface of the nozzle

Al Killed

Purity of Steel

Flow conditions and geometry of the submerged tube

Air leakages

Casting Speed Changes

Refractory Material Ladle/Tundish/ Casting Powder

Loss of Temperature

Reasons of Clogging

Several possible reactions have been proposed for alumina-graphite SENs such as:

$$SiO_2(s) + C(s) \rightarrow SiO(g) + CO(g)$$

$$Al_2O_3(s) + 2C(s) \rightarrow Al_2O(g) + 2CO(g)$$

Interface:

$$Al_2O(g) + 2CO(g) \quad Al_2O_3(s) + 2C$$

$$3SiO(g) + 2Al \rightarrow Al_2O_3(s) + 3Si$$

$$3CO(g) + 2Al \rightarrow 3C + \mathbf{Al_2O_3(s)}$$

$$\rightarrow$$

Effects of Clogging

Clogging is detrimental to steel cleanliness :

1. Dislodged clogs becomes trapped in the solidifying steel or can create undesired microstructure in the finished steel.

2. Causes restriction of steel flow and affects mold flow patterns, producing biased/turbulent flow and vortices.

3. Interferes with mold level control as the flow regulation device tries to compensate for clogging.

4. Constriction of inner nozzle diameter leads to reduced caster productivity and some times to premature termination of casting sequences.

Solutions For clogging

Change of SES after specific period of casting

Or

Use of Anti Alumina build up Liners inside the refractory body :

- **Low melting liner:** ISO mix, based on Calcia, Magnesia and Zirconia, reacts with Alumina generating low melting eutectics causing the liner to wash out of the nozzle

- **Permeable liners:** A permeable mix is used to blow high pressure argon into the nozzle to block the bonding of dispersed Al_2O_3 to refractory body

Solutions For clogging

- **High Silica liner:** The SiO_2 of the mix reacts with Mn originating low melting compounds which avoid Al_2O_3deposition

- **Carbon-free liner:** The elimination of Carbon from the mix of the liner during the preheating→creating a decarb layer

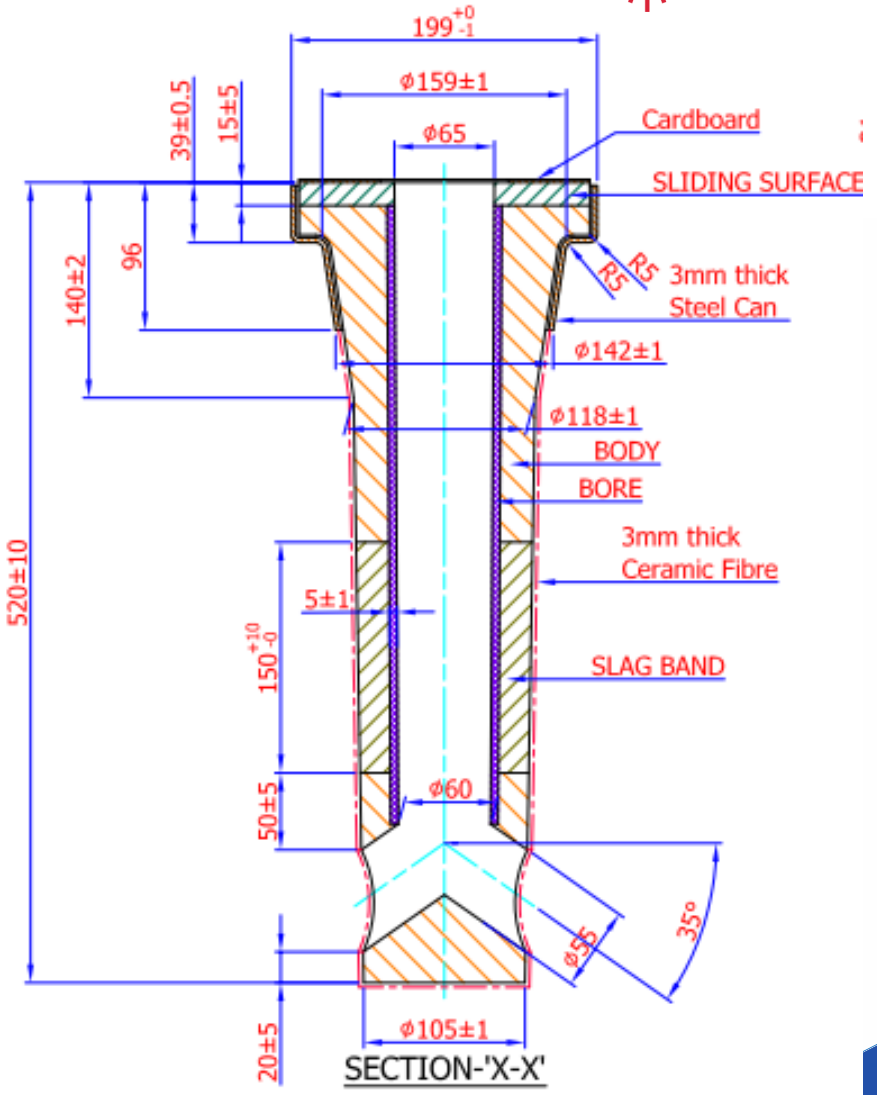
Or

To use carbon free compositions using special insulating Al_2O_3

Advantages of Carbon free Liner

- ✓ Retaining surface flatness in molten steel - No decarburization
- ✓ Eliminate source of oxygen; SiO(g), CO(g)- No reaction SiO(g), CO(g) and Al
- ✓ High insulating properties allows to use SES ***"Without preheating" as it*** suppresses the heat loss through refractory

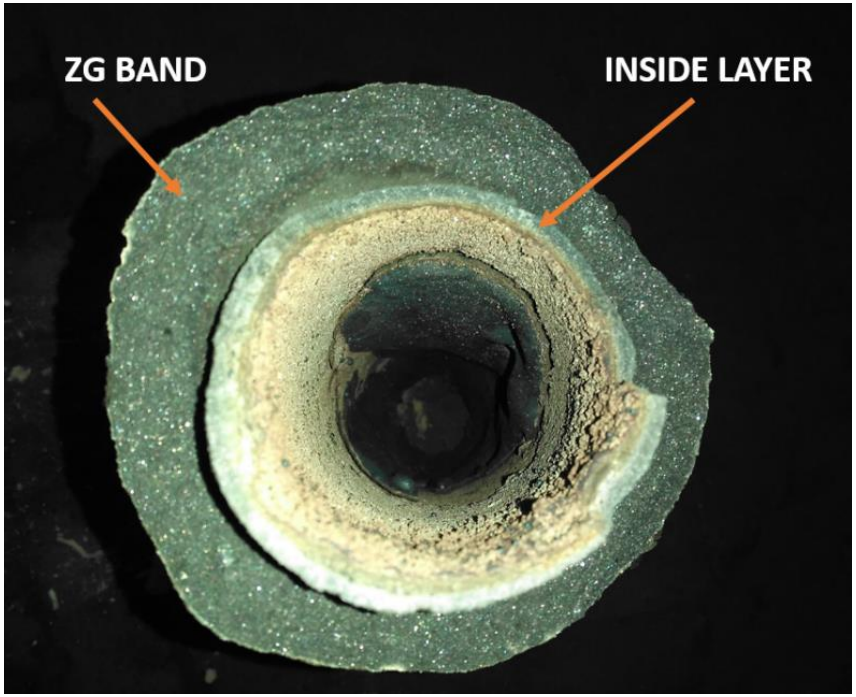
A SEN without clogging can keep initial outlet flow pattern in the mold



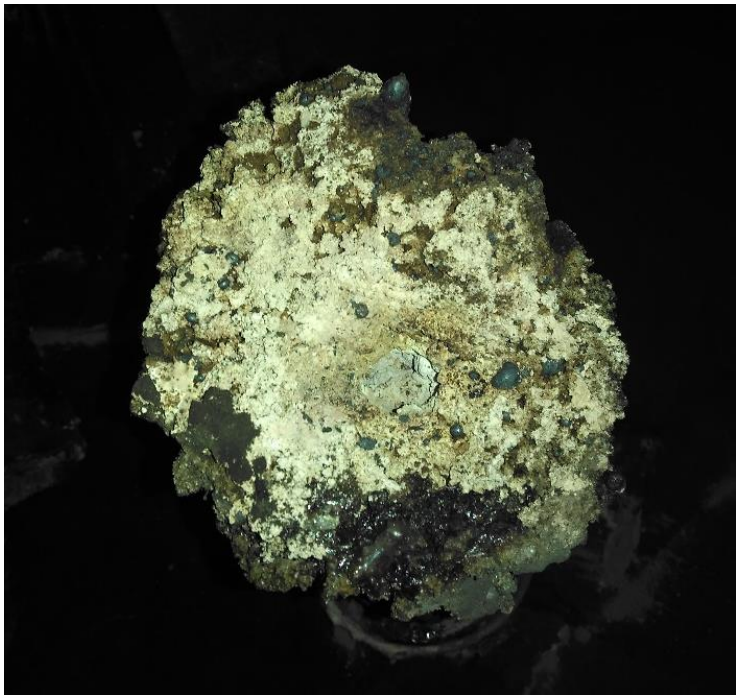
Case Studies

Case Study-1

- Trial sample had been tested at actual caster, which has 4 strands of section size 350*250 mm. (Integrated Steel Plant)
- One strand was used for regular SES in order to compare the results.
- Al_2O_3 content in steel is 0.35%.



Pic-1 Carbon free SES after use



Pic-2 Conventional SES after Use

Case Study-2

- Plant Name: Arcellor Mittal Vanderbijlpark, South Africa
- TCD SES tried in Two strand slab caster
- Trial Piece used in one strand and other stand used for competitor

Pic:3 Used piece after 7 heats

Results:

- ✓ Trial pieces went upto 7 heats without any issues.
- ✓ No clogging observed inside the barrel as well in ports.
- ✓ Mould level fluctuations found normal.

Conclusions

- ✓ Clogging avoided in the nozzles due to the presence of Carbon free liner as it hinders the formation of Oxygen bearing gases which in turn acts as agents for the formation of Al_2O_3 clusters around the refractories
- ✓ Plant trials showed positive results (Tried in two different steel plants)
- ✓ One of the significant findings of the trial was to use the sample piece with out preheating
- ✓ Pieces used without preheating and no thermal shock observed
- ✓ ***Inner liner not only helps to avoid clogging but also a provides superior thermal shock resistance***

THANK YOU