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”A Novel approach to reduce Torpedo ladle relining turnaround time “

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Introduction

Torpedo availability is critical for hot metal transportation from Blast furnaces to LD Shops. considering the limited fleet, which is required for daily production at Tata Steel, Jamshedpur plant. Low torpedo availability can lead to low HM buffer & interruption in HM supply to LD Shops. Relining is a major activity (longest downtime) of torpedo maintenance so reduction in torpedo relining turnaround time will increase the availability of torpedo.

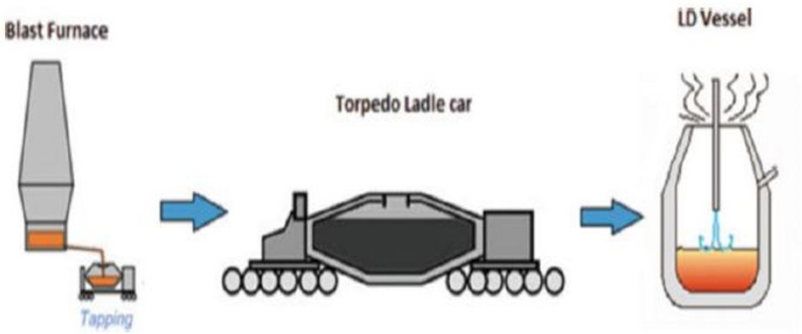
Torpedo ladle

Current challenges:

- High Hot metal production
- Carbon foot print reduction- Environment friendly
- Cost pressure
- Easy , flexible and safe workbility

Current Practices and methods(1/2)

- At Tata Steel - Jamshedpur works; a fleet of 48 refractory-lined, steel torpedo ladles are used to transport the hot metal from six Blast Furnaces to three LD shops.
- There are two types of torpedo ladle, consisting of 320Mt capacity and 200Mt capacity. .
- At present 21nos of 200t and 27nos 320 t TLCs are in fleet to transport 32000 tons of hot metal per day



Parameters	320t TLC	200t TLC
Vessel capacity with new lining	320t	200t
Hot metal temperature (deg C)	1550	1550
Weight of TLC (without refractory)	180 ton	113 ton
Weight of TLC (with refractory)	300 t (approx)	218t
Inside volume of vessel with new lining	51.23 m3	39.5m3
Available free board	2.27 m3	1.8m3
Overall height of car above rail top	4350 mm	4110 mm
Overall width of car	3500 mm	3428mm
Max. permissible shell temperature	300 deg C	300 deg C
Overall refractory thickness	400 mm	400 mm

Technical specification of Torpedo ladle cars

Current Practices and methods(2/2)

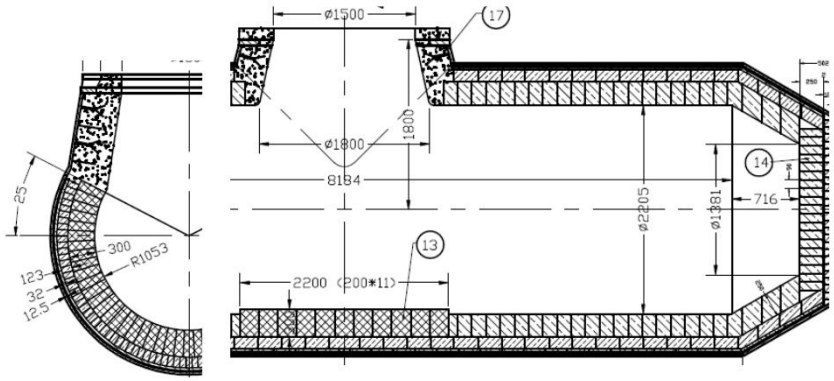


Fig. 2: Lining configuration of 200t torpedo ladle

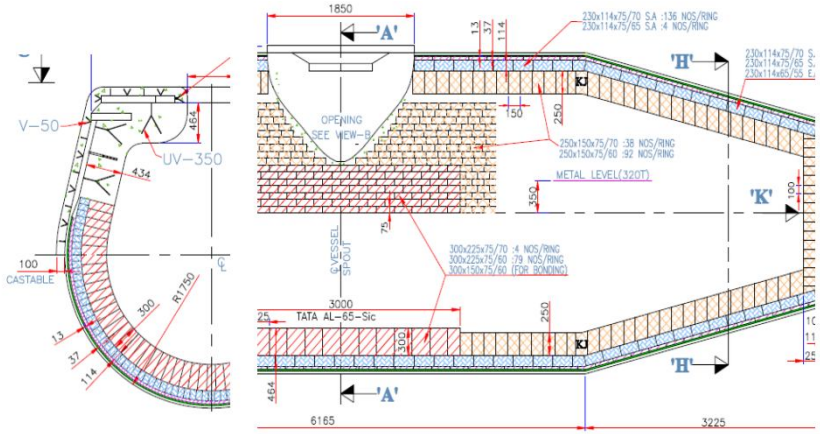
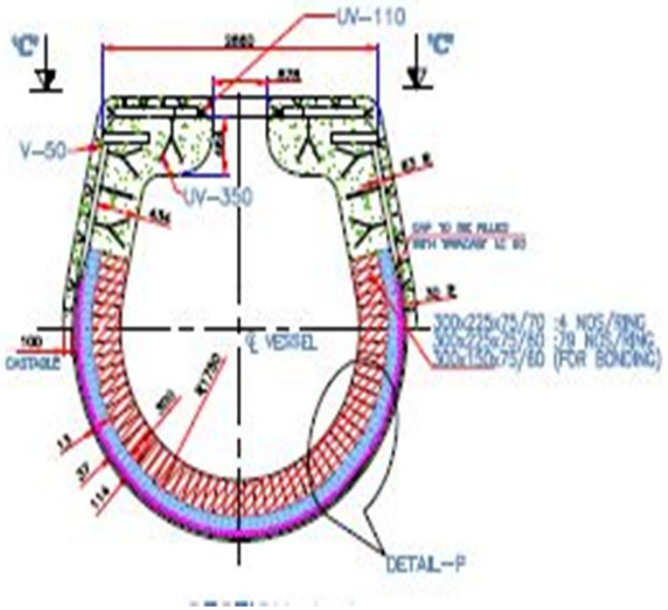


Fig. 3: Lining configuration of 320t torpedo ladle



Lining configuration of spout portion of 320t torpedo ladle

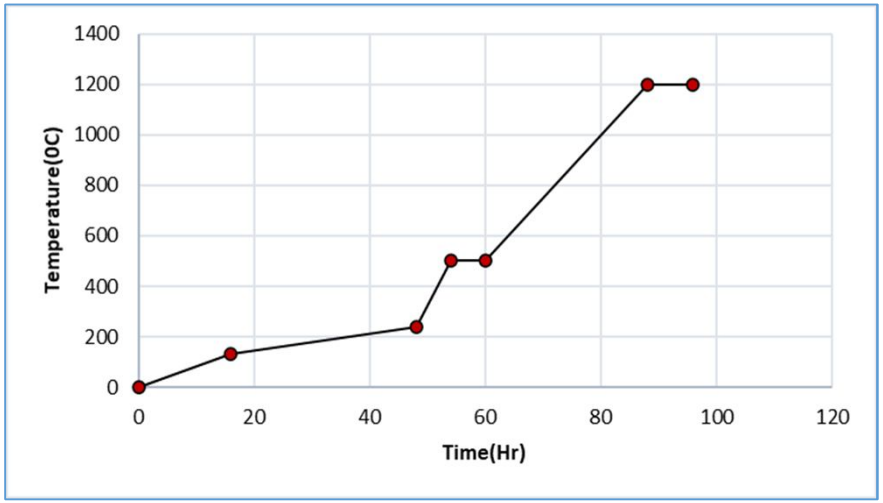
Activities performed for Torpedo repairing

Sl no	Activities details	Time(Hours)
1	Cooling	16
2	Dismentling	64
3	Mechanical+ Elecrical+other repair	48
4	Refractory relining	204
5	End wall lining, shield plate casting and end cover closing	24
6	Heating	96
	Total	452

Relining is a major activity (longest downtime) of torpedo maintenance. reduction in torpedo relining turnaround time will increase the availability of torpedo. Current turnaround time for a newly lined torpedo 452 Hours, which includes 96 hours. of preheating schedule.

Issues with current Spout Low cement castable:

- Higher drying time
- Low self life (9 months)
- formation of low melting compounds, namely, anorthite ($CaO \cdot Al_2O_3 \cdot 2SiO_2$) and gehlenite ($2CaO \cdot Al_2O_3 \cdot SiO_2$)
- **High energy consumption**



Existing Heating schedule of new relined torpedo

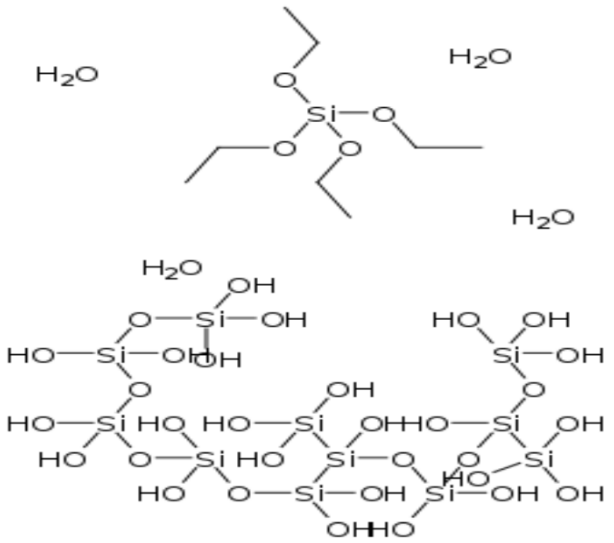
Introduction to No cement based castable (NCC)

Benefits of NCC over LCC :

- Reduced drying time and drying defects due to the absence of free water for mixing and permeable structure.
- Inherent formation of mullite in alumina compositions improves corrosion resistance and hot strength properties.
- Better high-temperature properties due to absence low melting compounds in CaO–Al2O3–Fe2O3 and CaO–Al2O3–SiO2 systems.
- Better high-temperature properties result in longer campaign life and reduced downtime of operation.

Future of castable : NCC

Drying mechanism of Silica SOL



Silica Sol Gelation Process

SiOH HOSi = H_2O + Si --- O --- Si

Their main characteristics are shown in **Table** and compared with the existing torpedo spout castable.

Sample type	Existing castable	Trial sample-1 (T-1)	Trial sample-2 (T-2)
Base material/ Bonding type	High Alumina Cement bonded	Mullite based Silica Sol bonded	Al2O3-SiC based Silica Sol bonded
CHEMICAL ANALYSIS(%)			
ELEMENT DESCRIPTION	ANALYSIS		
CaO	2.42	0.6	0.5
SiO2	9.9	31.28	27.22
Fe2O3	1.07	1.04	1.18
Al2O3	83.03	63.36	56.47
TiO2	2.26	1	1.09
SiC	-	-	11.78
OTHER PROPERTIES			
WATER (%)	6	-	-
Silica SOL (%)	-	8.3	8.9
@110^{0}C BULK DENSITY(g/cc)	2.8	2.42	2.42
@110^{0}C POROSITY (%)	14.7	14.22	15.2
@110^{0}C CCS kg/cm2	640	600	580
@1000^{0}C BULK DENSITY(g/cc)	2.77	2.43	2.42
@1000^{0}C CCS (kg/cm2)	780	825	927
@1000^{0}C PLC(%)	-0.24	-0.06	-0.04
@1400^{0}C BULK DENSITY(g/cc)	2.73	2.44	2.44
@1400^{0}C CCS (kg/cm2)	867	945	962
@1400^{0}C PLC(%)	0.59	-0.19	-0.1
Corrosion Index	++	++	+
RTE @1000^{0}C(%)	0.75	0.5	0.62
Thermal conductivity' @800^0 C(W/mK)	1.78	1.47	1.46

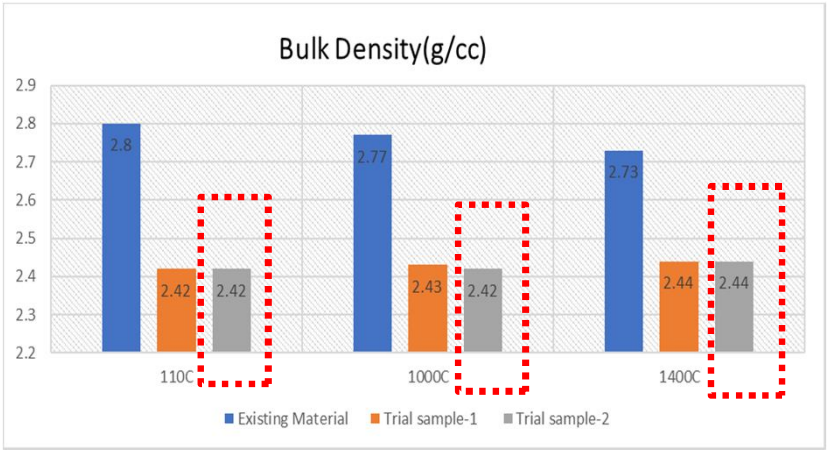
Chemical composition

- Very low lime percentage found in case of both trial Sol bonded castables due to usage of silica sol as binder in place of high alumina cement.
- Trial -2 contains Silicon carbide, whereas no SiC is present in trial-1 and existing castable.
- Less alumina percentage found in trial NC castables.

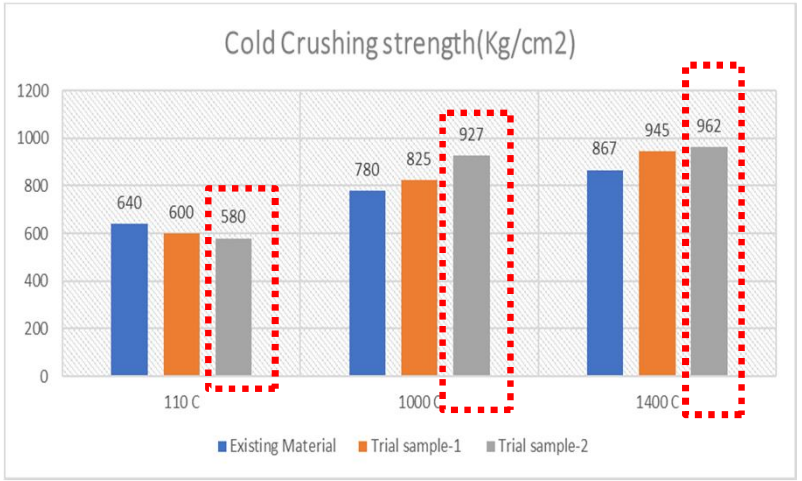
- ✓ Existing castable : LCC HAC bonded
- ✓ Trial Sample -1 : Mullite based Silica Sol bonded castable
- ✓ Trial sample-2 : Alumina- SiC based Silica Sol bonded castable

Results and discussions

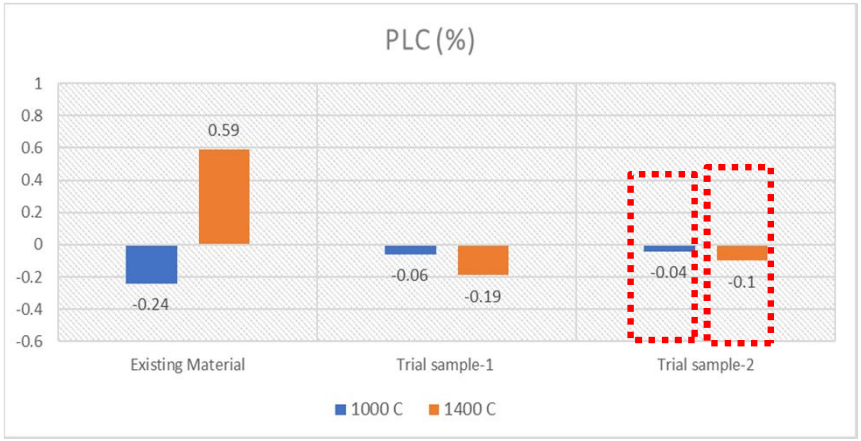
Physical and other properties



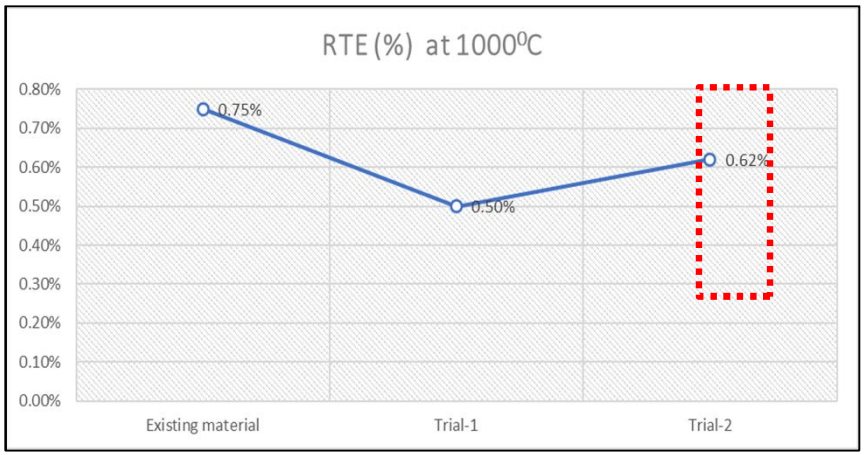
Bulk density values at three different temperature



Strength values at three different temperature

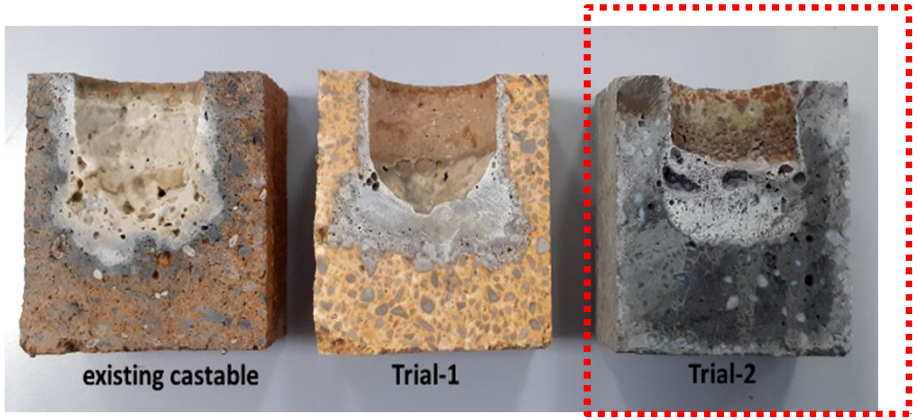


PLC values at three different temperature



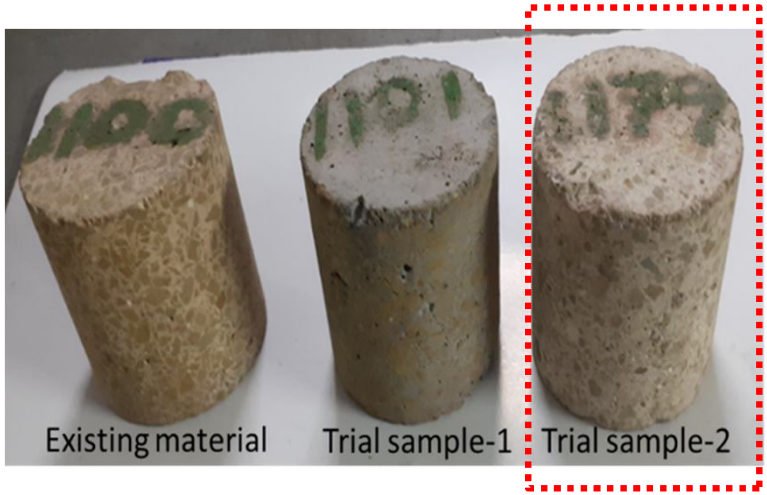
Thermal expansion % at 1000 deg C

Thermomechanical properties

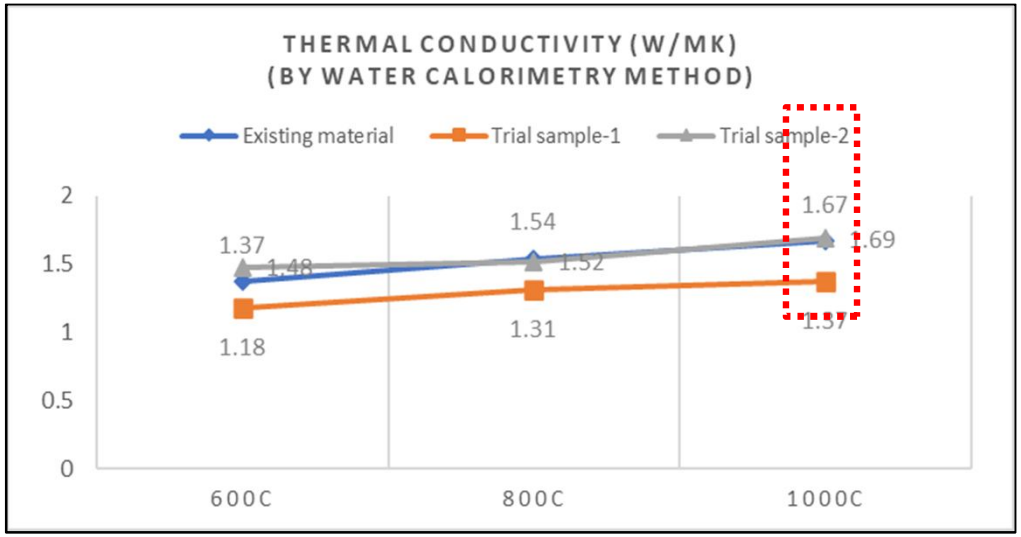


Corrosion test with BF slag after firing at 1500 C/ 3hrs

Corrosion index		
Existing material	72.20%	++
Trial -1	80%	++
Trial -2	26.50%	+



Results of thermal spalling after 50 cycle



Results of thermal conductivity test

Application of Trial castable

SiC based sol bonded castable shown better refractory properties (Trial Sample-2) as compared to the existing cement bonded castable and the other mullite based sol bonded material.

- Better high temp. properties
- High corrosion resistance against BF slag
- Comparable thermal conductivity values

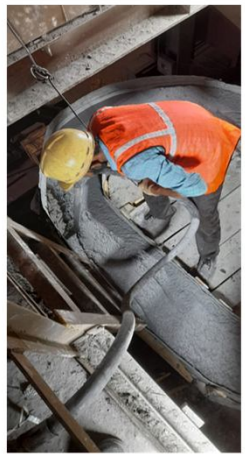
Based on all the analysis; **SiC based sol bonded castable** finalized to take trial for Torpedo Mouth application and to validate the actual performance at the site.

Condition of torpedo spout after preheating

TRIAL DETAILS

Date of Trial	15-05-2022
Torpedo No	41
Material used	Sol bonded castable
Application area	Torpedo mouth/ Spout
Qty of material used	~ 8Mt
Binder used	Silica Sol
Binder addition (%)	9.5
Template removed	after 24hrs of casting
Heating period	62 hrs

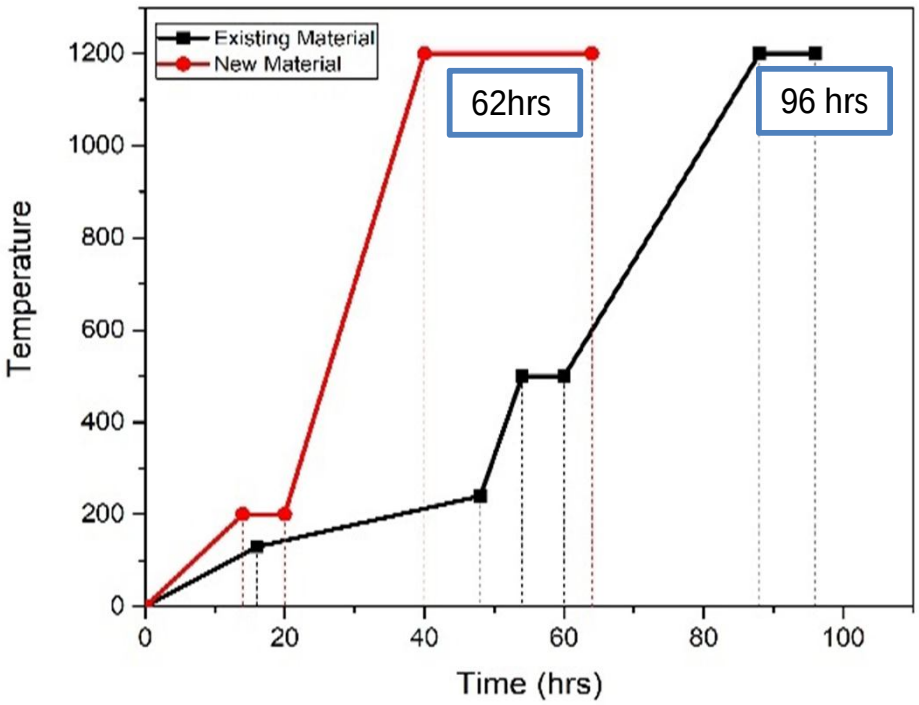
Spout templates



During casting

after casting

Comparative heating schedule existing Vs Trial



Findings :

- ✓ Reduced drying time by 34hrs
- ✓ Very long shelf life (18 months)
- ✓ Reduction of CO gas consumption by 30%
- ✓ Lower consumption of repair material (like gunning consumption) due better high temp. properties
- ✓ Reduced Shell temperature within the safety norms (<300 Deg C) due to lower thermal conductivity values
- ✓ Enhanced corrosion resistance due to presence of SiC
- ✓ longer campaign life and reduced downtime of operation.

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