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Improvement in ladle technology for conservation of heat energy

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Abstract
Currently steel industries are the largest energy consuming sector in the world, accounting for 15% of world's industrial energy consumption & the total cost of producing steel 20% is spent on energy. The increasing cost of energy and its current and future availability shows the need to refocus attention on energy conservation. During processing & transportation of liquid iron in ladles there is continuous reduction of temperature from refractory lining due to heat losses from conduction & radiation. In order to keep a usable pouring temperature into the mould, these heat losses must be compensated by excess tapping temperatures in the furnace. This in turn leads to increase cost of heating the iron as well as higher alloy consumption & refractory wear. The research primarily focused on reducing the consumption by decreasing the tapping temperature. Therefore a layer of high strength insulating material behind a safety lining was considered. The benefits of using the insulation layers are lower shell temperatures, the improvement of liquid iron temperatures, these results in improved lower energy consumption, a reduction in furnace refractory consumption. The use of insulating ladle reduces energy consumption by 1.39% and ladle outer shell temperature reduced by 98°C.

Keywords: insulating material; heat loss; ladle shell temperature; furnace tapping temperature; energy consumption

1. Introduction

The introduction of continuous casting & the enlargement of secondary metallurgy in steel plant caused that the ladle ceased to be just a media/ container for transport of molten metal from the primary unit (Furnace Section) to the caster. Ladles are generally refractory-lined, vertical cylindrical vessels that are closed at one end and usually open at the top and a small off centre casting nozzle in the base. They consist of an external steel shell (20-100 mm thick), and several layers of internal refractory lining (up to 400 mm). Ladle size is depending upon the capacity of the molten metal to be poured. When heat is ready for tapping from the furnace, then molten metal is poured into a ladle and transported, usually via an overhead crane, to the casting station. A small difference between targeted and achieved temperatures on teeming may have very negative consequences for surface quality, cleanliness, tundish flow through, nozzles, casting schedules, energy economy, etc.

During processing liquid iron in ladles & holders, there will be a continuous reduction of temperature due to heat losses from conduction through refractory lining & radiation from hot surfaces of ladle. In order to keep usable pouring temperature into the mould, these heat losses must be compensated by excess tapping temperature in the furnace. This in turn leads to increase cost of heating the iron as well as higher alloy consumption & refractory wear. By means of effective heat conservation, the losses & the consequences can be minimized & thereby reduce the overall cost of produced iron.

Fig 1: Ladle

Tapping of the steel melt from the furnace into the ladle is accomplished by a very rapid drop in the melt superheat. The time for which the melt can be maintained in its superheated state depends on the tapping temperature, the extent of ladle preheat, the time taken to fill the ladle, ladle refractory material properties & the thickness of slag cover. Tapping temperature loss can thus be attributed to the following reasons; heat loss by pouring stream to the atmosphere by radiation, heat loss by convection to the slag layer & heat loss to the ladle walls as the ladle is filled. Once the ladle is full, the melt is held in the ladle for some time before casting, in this intervening period, the melt continuous to lose heat to the ladle walls & to the atmosphere. These process assuming a linear drop in the hot face temperature from 1650°C to 1560°C in one & half hour. The use of insulating linings allows foundries to adopt a lower tapping or holding temperature practice and to reduce the variation in metal pouring temperatures. This results in improved control of metal chemistry, lower energy consumption, a reduction in furnace refractory consumption, and fewer slag inclusions and temperature-related casting defects.

2. Need of Insulation

2.1 To Maintain Ladle Lining Temperature

The temperature of ladle lining will directly affect the quality of liquid steel and ladle's service life. The reason is that when molten steel with temperature 1650°C is poured into the ladle, the working layer of ladle lining is heat insulation material & if working layer did not reach the required temperature of 1000°C during ladle baking, the molten steel liquid is directly injected into ladle that will cause great thermal shock to the working layer and bottom of ladle, this will causes the damage of working layer and refractory material of ladle, thus reducing the service life of the ladle. Meanwhile, molten steel will lose a lot of heat in the ladle, and then molten steel temperature will drop dramatically.

2.2 To Reduce Tapping Temperature

Survival of industries in such a period where rates of raw materials & electricity increasing continuously, it becomes essential for each company to reduce non value added activities to compensate this hike. Now a day's energy saving is much more essential for industry where rates of electricity is increasing drastically. By reducing tapping temperature of molten metal in induction furnace electricity can save.

2.3 To Maintain Molten Metal Temperature in Ladle

Heat loss from ladle badly affect the quality of billet & TMT bar production in case of hot rolling as molten metal remains in ladle nearly for 90 min & during that period temperature of molten metal drops continuously as time progress, so temperature goes below required temperature & molten metal gets solidified so fluidity of metal gets affected & billets having less temperature may leads to break out & rolling mill roughing role crack so maintaining temperature in ladle becomes important for smooth casting & further work.

2.4 To Reduce Skull Formation

Casting temperature of the melt is of paramount importance to the solidification behavior of the castings. A considerable loss in heat content of the melt occurs from the time it is tapped to the end of casting & is evident from the accompanying fall in temperature. When molten metal enters in the ladle the temperature is more than 1600°C. Ladle directly contact with ambient temperature so due to this temperature variation heat transfer takes place & temperature of molten metal is reduced due to heat transfer. When temperature drop occurs in the ladle, solidified material produced inside boundaries of ladle called "skull". Skull formation is low if heat transfer in ladle is less.

2.5 To Reduce Ladle Shell Temperature without Compromising Volume of Ladle

In order to safely obtain the benefits of thinner linings and longer campaigns in steel ladles, it is necessary to insulate the lining. When the ladle shell is subjected to high temperatures, it is subject to warping, cracking and because of these issues, loss of containment of the liquid steel. The steel shell loses strength, expands, contracts, and permanently deforms from over exposure to heat.

2.6 To Reduce Heat Loss

Efforts to minimize heat loss of liquid steel through the ladle lining led to the idea of integration of high quality insulating layer between permanent lining & ladle steel shell. Ladle heat content plays a significant role in this drop in temperature & hence efforts are always directed towards minimizing the heat loss & maximizing the heat content. Preheating the ladles is an established procedure adopted to reduce the temperature loss from the melt.

3. Methodology

3.1 Components in Ladle System

i) Ladle: The ladle ceased to be just a media/container for transport of steel from the primary unit (Furnace Section) to the caster. Ladles are commonly used to transport molten metal from melting furnaces to casting stations in metal production facilities. Ladles are generally cylindrical, with an open top, and a small off centre casting nozzle in the base. They consist of an external steel shell (20-100 mm thick), and several layers of internal refractory lining (up to 400 mm).

ii) Silica Bricks: Ladle is a bucket shaped steel vessel having thickness of steel sheet about 30 mm. For preparing safety lining silica sand bricks are used in inner shell. After safety bricks safety linings are prepared which is of silica ramming mass which holds molten metal. There are three sizes of bricks which are commonly used for preparing safety lining.
   1) 230*115*75 mm
   2) 230*115*50 mm &
   3) 230*115*40 mm

iii) Ladle Former: Ladle former is a conical shaped Vessel made up of mild steel plate having thickness 3 mm. This former is placed in ladle to support patching. It is placed in ladle vertically when bricks are applied to the ladle inner shell. Former creates wall of ramming mass when ramming mass inserted in the space between ladle inner shell made up of bricks & former. Former can be removed or can be melted after patching is done. If we keep former in ladle while tapping it will melt in first heat of ladle.

iv) Ramming Mass: Ramming mass is a silica Quartz Powder having different sizes from fine powder to 5 mm. Ramming mass contains approx. 1 % boric acid & it works as a binder. Ramming mass is used for making refractory lining in between ladle inner shell & molten metal.
   Refractory materials should have an ability to withstand;
   1) high temperature & sudden change of temperature
   2) action of molten metal slag & hot gases
   3) load & abrasive force

4) It must have low thermal conductivity as well as ability to conserve heat.

3.2 Preparation of Ladle Lining (Traditional Ladle)

In case of Traditional method (Without Ceramic Insulating Boards) silica bricks fitted directly on ladle inner shell by using “WhyHeat A” cement & this lining is called safety lining. Each bricks placed one over other vertically

Table 1: Properties of Ceramic Boards

Physical Properties	HS-45
Classification Temperature	1260°C
Chemical Compositions (%) (IS : 12107/ XRF	
Al2O3	49-53
SiO2	33-37
CaO	9-12
Loss on ignition (%)	< 10
Density (Nominal) Kg/ M3	720
Modulus of Rupture KPa < 25 mm Thick	3000
Modulus of Rupture KPa > 25 mm Thick	2000
Linear Shrinkage (%) – 24 Hrs (Max)	1.0 (1200 °C)
Thermal Conductivity W/MK	
600 ◦C (Mean Temperature)	0.16
Thickness (mm)	
5	√
10	√
12	√
15	√
Physical Properties	HS-45
Classification Temperature	1260°C
Chemical Compositions (%) (IS : 12107/ XRF	
Al2O3	49-53
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Thermal Conductivity W/MK	
600 ◦C (Mean Temperature)	0.16
Thickness (mm)	
5	√
10	√
12	√
15	√

starts from bottom till the top of ladle. Make sure that bricks lining done all around circumpherentially at inner side. Next step is to patch with ramming mass over that silica bricks. For patching with silica ramming mass, firstly place ladle former inside the ladle & match its center with ladle bottom center, once the center is match then fill the gap between safety lining & ladle former with ramming mass & rammed this powder with ramming tool till it compact properly & no air gaps remain in it. Layer of ramming mass is called working layer & it holds molten metal in between these linings.

3.3 Ladle Working Cycle

When we have to take ladle for tapping first time it has to be preheated by means of oil preheater to gain required initial lining temperature to avoid thermal shocks. When ladle lining is red hot then only it becomes useful for tapping. Next to preheating tapping of molten metal from furnace is done in ladle when molten metal temperature in furnace reaches near about 1650°C. Once tapping done in ladle it sends to the Concast department where ladle holds for some time to complete purging & alloy addition if required. When molten metal gain required temperature for casting then it placed on turret for casting operation.

Casting process requires about one hour, after completion of casting ladle sends to remove slag & cleaning ladle nozzle & for further maintenance work if required. After completion of maintenance work again same process of preheating & tapping is done on traditional ladle. In every ladle cycle ladle needs to be preheated as there is much loss of heat through ladle lining so there is wastage of furnace oil as there is use of oil preheater to preheat ladles & every time tapping temperature has to increase as no retention of heat in ladle. So it becomes essential to prevent loss of heat from ladle shell.

3.4 Selection of an Insulating Material

Insulating material must have following properties,

1. Insulating material must have high strength & low thermal conductivity
2. Insulating material should have minimum shrinkage.
3. Easy to install lining in a way that results in consistent properties.
4. Thermal properties that minimize the heat losses from the steel melt.
5. Mechanical properties for prevention of failure from impact of the tapping stream & thermal cracks.
6. Insulating material should chemically inert to melt & slag for prevention of lining erosion & alloy contamination.

3.5 High Strength Ceramic Fiber Board (Insulating Tiles)

Fig 2: Ceramic Fiber Boards

High strength ceramic fiber Boards are having high compressive and flexural strength and good resistance to erosion from gas flow than normal Ceramic fiber boards.

High strength Boards are designed to meet the toughest knocks and pressure maintaining its strength over a long productive life. It has low shrinkage compared to other fiber products. Ceramic fiber is a low thermal mass insulation material, which has revolutionalised the furnace design lining systems. Ceramic fiber is an alumino silicate material manufactured by blending and melting alumina and silica at temperature of 1800 – 2000°C and breaking the molten stream by blowing compressed air or dropping the melt on spinning disc to form loose or bulk ceramic fiber.

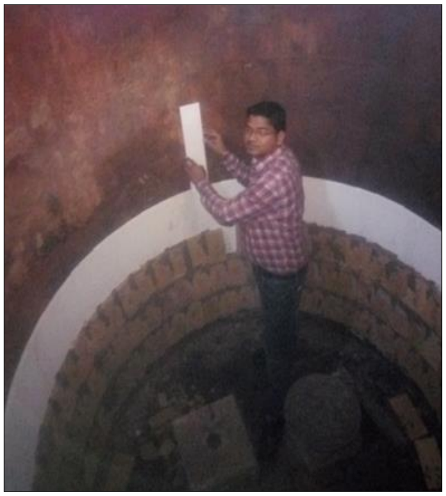

Fig 3: Ladle with Insulation

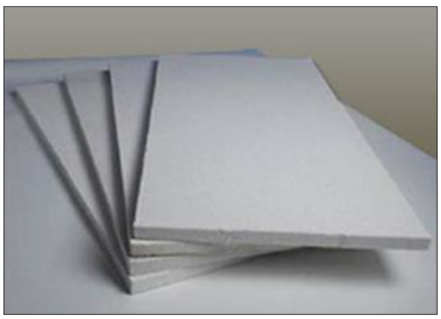

Fig 4: Ceramic Fiber Boards

4. Results & Discussions

4.1 Process Parameters

Modern ladle technique uses insulation of ceramic fiber board to the ladle. These ceramic boards applied to the inner side of the ladle shell & over which silica bricks as a safety lining. The working layer is formed of ramming mass over safety lining. Ceramic boards have less thermal conductivity & good strength.

Furnace molten metal temperature as well as ladle shell temperature is most important factors. For taking furnace molten metal temperature we used R type thermocouple instrument which gives accurate reading ranges from 1100°C to 1700°C & for ladle outer shell temperature we used Infrared Thermometer which gives accurate temperature up to 500°C.

Our main consideration is to save temperature drop in ladle via conduction, convection & radiation through ladle shell. Due to saving in drop page we can take less lifting temperature on CCM which may directly affects furnace tapping temperature. For example, Consider if we saved 10 °C temperature drop in ladle then for casting we can lift ladle with 10°C less temperature (Suppose 1580°C instead of 1590 °C), so from this assumption we can say that we can save electricity which can be used for increasing this 10°C temperature. By calculating actual temperature drop & saving electricity we can calculate actual saving in rupees & other related benefits.

Comparative study of insulated & non insulated ladle will show better result & for that we require ladle outer shell temperature before & after tapping which will show how much temperature is raised against tapping temperature of furnace. For same patching life of insulated & non insulated ladle the shell temperature will show temperature drop from walls.

While casting ladle holds molten metal about 60 min & much of the drop page occurs at that time so while casting we can take ladle shell temperature after some specific time. After calculating saving of droppage in degree Centigrade it

Will possible to calculate required unit to raise that temperature in furnace so from that we can calculate

Approximate saving in Rupees by incorporating insulation.

i) Ladle Life: Ladle life is one of the most important Parameter as ladle life increases heat losses through ladle shell also increases because thickness of safety lining goes on decreasing. So it is important to monitor ladle shell temperature for each changing ladle life.
ii) Furnace Tapping Temperature: Furnace tapping temperature of each lot is important for calculate heat loss analysis as we have to minimize furnace tapping temperature which will leads to save power consumption & for calculation consider molten metal temperature before tapping.
iii) Molten metal temperature on CCM: Ladle molten Metal temperature at CCM indicates how much temperature we have to drop for further process due to which we can do smooth operation. We have to keep molten metal approximate 60 min, in ladle so ladle temperature is essential for further process.
iv) Lifting temperature: Lifting temperature is the Temperature of molten metal taken for casting process. This temperature suggests that at what temperature casting process will smooth. Less lifting temperature will help to take less tapping temperature
v) Ladle outer shell temperature: This temperature Suggests the heat loss through the ladle. More shell temperature means more heat loss, so our aim must to reduce ladle outer shell temperature
vi) Power consumed in KWH: This is the output Factor which depends on tapping temperature. Power consumption is directly proportion to tapping temperature. Our main objective is to reduce power consumption.

4.2 Readings of Insulated & Non Insulated Ladles

Table 2: Data of Non Insulated Ladle

Ladle Life	Furnace Tapping Temp. °C	Ladle molten metal temp. on CCM °C	CCM Lifting Temp. °C	Tundish Molten Metal Temp. in °C	Ladle outer shell temp. after half casting done °C	Power Consumed in KWH
138	1624	1608	1589	1532	291	14690
139	1621	1605	1584	1531	302	14156
140	1627	1612	1591	1532	313	15086
141	1624	1608	1587	1530	325	14182
142	1636	1615	1603	1535	318	15790
143	1631	1615	1598	1530	326	15282
144	1628	1616	1589	1530	346	15112
145	1624	1612	1586	1529	337	14747
146	1629	1615	1589	1530	356	14886
147	1634	1618	1592	1530	363	13746
148	1642	1622	1606	1535	352	15818
149	1631	1615	1598	1533	364	15225
150	1626	1608	1586	1528	372	14720
151	1620	1604	1589	1529	381	14044
152	1627	1612	1594	1531	394	15339
153	1618	1599	1591	1530	387	14807
154	1624	1608	1593	1530	398	14345
155	1621	1601	1598	1531	409	14860
Avg.	1627.06	1610.72	1592.39	1530.89	351.89	14824

Table 3: Data of Insulated Ladle

Ladle Life	Furnace Tapping Temp. °C	Ladle molten metal temp. on CCM °C	CCM Lifting Temp. °C	Tundish Molten Metal Temp. in °C	Ladle outer shell temp. after half casting done °C	Power Consumed in KWH
138	1619	1606	1593	1535	205	15185
139	1616	1604	1585	1533	211	14952
140	1608	1596	1576	1531	209	14536
141	1613	1601	1579	1531	222	14182
142	1608	1597	1573	1530	231	15121
143	1610	1598	1577	1531	226	14863
144	1607	1594	1575	1530	235	14872
145	1603	1590	1572	1529	241	14624
146	1629	1616	1604	1536	247	15491
147	1609	1597	1589	1534	238	14761
148	1606	1593	1577	1532	252	13632
149	1601	1589	1572	1529	264	14956
150	1607	1595	1573	1529	271	14677
151	1597	1586	1576	1530	263	13359
152	1608	1596	1582	1532	278	15260
153	1611	1591	1578	1531	287	14713
154	1608	1595	1581	1531	298	13299
155	1613	1600	1585	1531	311	14641
Avg.	**1609.61**	**1596.89**	**1580.39**	**1531.39**	**249.39**	**14618**

4.3 Graphs of Non Insulated Ladle Vs Insulated Ladle

Graphs showing various parameters of non insulated ladle & insulated ladle Vs Ladle life

On X- Axis: - Ladle Life & On Y-Axis:- Furnace Tapping Temperature in °C

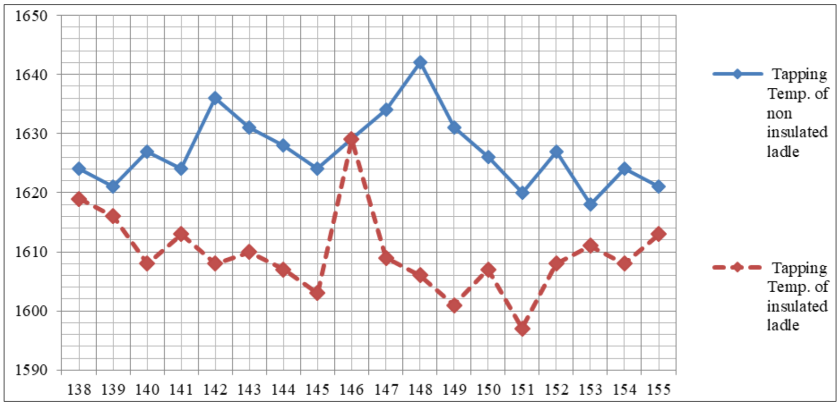

Fig 5: Tapping Temperature of Non Insulated Ladle & Insulated Ladle in °C Vs Ladle Life

On X- Axis :- Ladle Life & On Y-Axis :- Molten Metal Temperature On CCM in °C

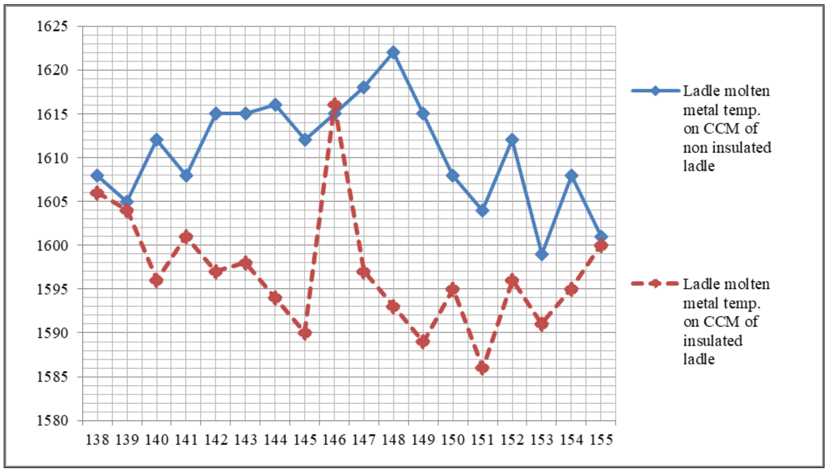

Fig 6: Molten Metal Temperature on CCM of Non Insulated Ladle & Insulated Ladle in °C Vs Ladle Life

On X- Axis :- Ladle Life & On Y-Axis :- CCM Lifting Temperature in °C

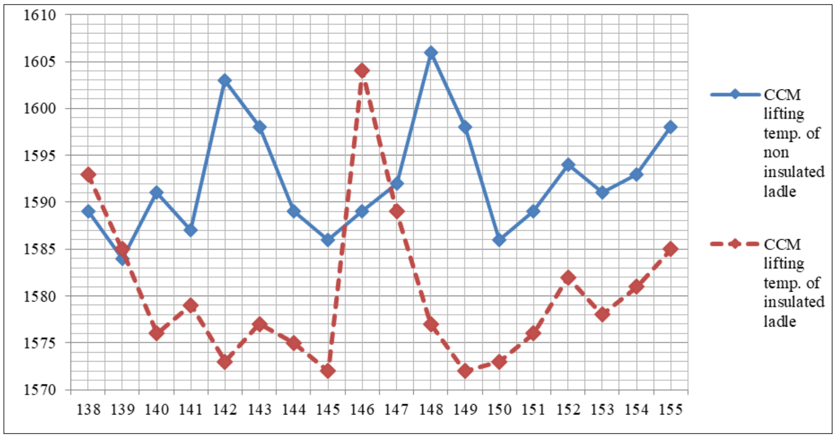

Fig 7: CCM Lifting Temperature of Non Insulated Ladle & Insulated Ladle in °C Vs Ladle Life

On X- Axis: - Ladle Life & On Y-Axis:- Tundish Temperature in °C

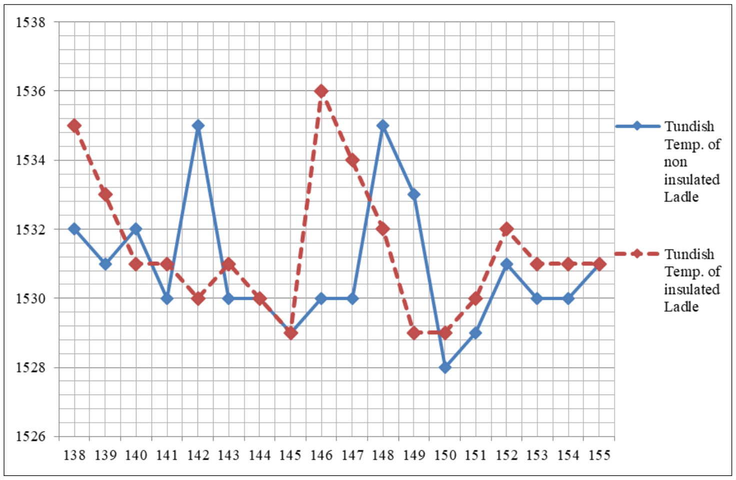

Fig 8: Tundish Temp. of Non Insulated Ladle & Insulated Ladle in °C Vs Ladle Life

On X- Axis :- Ladle Life & On Y-Axis :- Ladle Outer Shell Temperature in °C

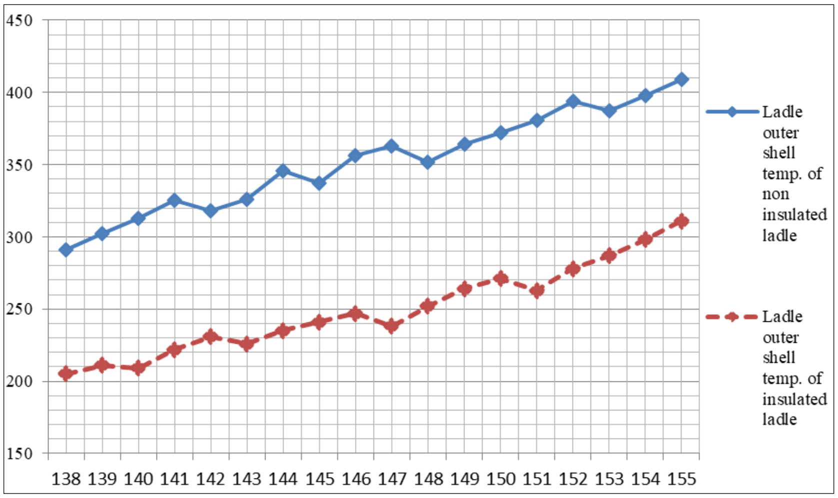

Fig 9: Ladle Outer shell Temp. of Non Insulated Ladle & Insulated Ladle in °C Vs Ladle Life

On X- Axis: - Ladle Life & on Y-Axis:- Power consumed in KWH

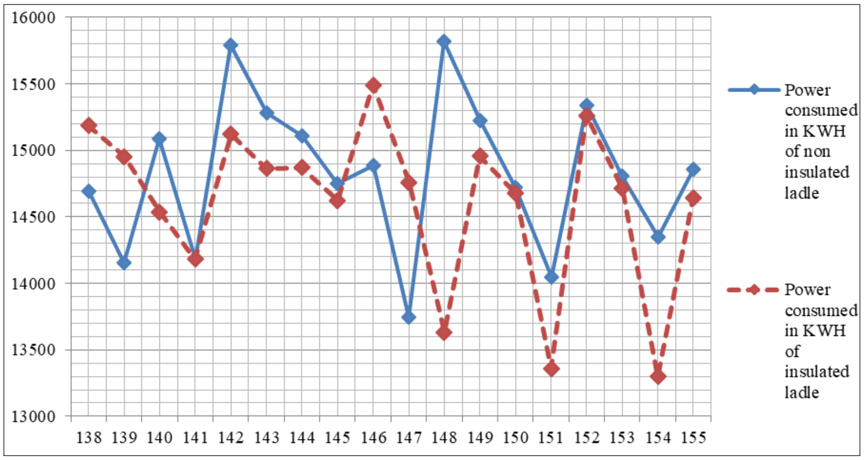

Fig 10: Power Consumption in KWH of Non Insulated Ladle & Insulated Ladle Vs Ladle Life

4.4 Result Analysis

Table 4: Table showing improvements after giving insulation

Parameters	Furnace Tapping Temp. °C	Ladle molten metal temp. on CCM °C	CCM Lifting Temp. °C	Tundish Molten Metal Temp. in °C	Ladle outer shell temp. in °C	Power Consumed in KWH
Ladle without insulation	1627.06	1610.72	1592.39	1530.89	351.89	14824
Ladle with insulation	1609.61	1596.89	1580.39	1531.39	249.39	14618
Saving	17.45°C	13.83°C	12.0°C	0.5°C	102.5°C	206 KWH
Improvement in %	1.072 %	0.86 %	0.75 %	0.03%	29.13 %	1.39%

The table no II, III, IV & Graphs showing comparative study of various parameters of insulated and non insulated ladles respectively. The comparative study of these two ladles is self explanatory & the average readings explain the difference in insulated & non insulated ladle. The comparative study will explain the need of insulation of Ceramic boards.

Figure no. 05 shows comparison of tapping temperature of insulated & non insulated ladles having same ladle life. From graph, dark line shows tapping temperature of non insulated ladle & dotted line shows tapping temperature of insulated ladle.The average tapping temperature of non insulated ladle is 1627.06°C & that of insulated ladle is 1609.61°C, means it is clear that tapping temperature of insulated ladle is reduced by 17.45°C than that of non insulated ladle which is approx 1.072 % improvement. Tapping temperature has great importance as it directly affect the power consumption because if tapping temperature is more means the molten metal will consume more power to superheat same liquid metal, which is undesirable because it is only loss to the company. More tapping temperature leads to increased cost of heating the iron, as well as higher alloy consumption and refractory wear.

Figure no. 06 shows comparison of molten metal temperature on CCM of insulated & non insulated ladles having same ladle life where dark line shows molten metal temperature on CCM of non insulated ladle & dotted line shows molten metal temperature on CCM of insulated ladle. The average molten metal temperature on CCM of non insulated ladle is 1610.72°C & insulated ladle is 1596.89°C, means it is clear that molten metal temperature of insulated ladle is reduced by 13.83°C than that of non insulated ladle which is approx 0.86 % improvement. The difference between Tapping temperature & molten metal temperature on CCM in case of non insulated ladle is 16.34°C & in case of insulated ladle is 12.72°C. From the above statement we can say that the heat loss in between tapping to ladle reaching on CCM is less in case of insulated ladle. Cooling rate of insulating ladle is less as compared to non insulating ladle.

Figure no. 07 shows comparison of lifting temperature on CCM of insulated & non insulated ladles having same ladle life where dark line shows lifting temperature on CCM of non insulated ladle & dotted line shows lifting temperature on CCM of insulated ladle. The average lifting temperature on CCM of non insulated ladle is 1592.39°C & insulated ladle is 1580.39°C & also from graph it is clear that lifting temperature on CCM of insulated ladle is less than that of non insulated ladle. The reason behind less lifting temperature of insulated ladle is that it holds heat for long time & let not to loss heat through ladle shells so it maintains required heat in ladle lining.

Figure no. 08 shows comparison of tundish temperature of insulated & non insulated ladles having same ladle life where dark line shows tundish temperature of non insulated ladle & dotted line shows tundish temperature of insulated ladle. The average tundish temperature of non insulated ladle is 1530.84°C & insulated ladle is 1531.39°C & also from graph it is clear that tundish temperature of insulated ladle is more than that of non insulated ladle. The reason for more tundish temperature of insulated ladle than non insulated ladle even insulated ladle has less lifting temperature is that insulated ladle holds more heat in ladle & let not to loss heat so molten metal temperature in ladle remains hot so it maintains tundish temperature.

Figure no. 09 shows comparison of ladle outer shell temperature of insulated & non insulated ladles having same ladle life where dark line shows ladle outer shell temperature of non insulated ladle & dotted line shows ladle outer shell temperature of insulated ladle. The average ladle outer shell temperature of non insulated ladle is 351.89°C & insulated ladle is 249.39°C & average shell temperature reduction is about 102.5°C for insulated ladle as well as improvement in outer shell temperature is about 29.13%.Throughout the campaign the shell temperatures remain stable, indicating that minimal degradation of the Insulation Board during service. A cooler shell results in less deformation & more ladle life. Less ladle shell temperature means less heat loss through the ladle shell means more heat content in ladle & less distortion of ladle shell.

Figure no. 10 shows comparison of power consumed in KWH of insulated & non insulated ladles having same ladle life where dark line shows power consumed in KWH of non insulated ladle & dotted line shows power consumed in KWH of insulated ladle. The average power consumed in KWH of non insulated ladle is 14824 KWH & insulated ladle is 14618 KWH & also from graph it is clear that power consumed in KWH of insulated ladle is less than that of non insulated ladle. The average reduction in power consumption in KWH for insulated ladle is 206 KWH which is about 1.39% improvement. From the above statement it is clear that insulation can save lot much power & can be beneficial for cost cutting. If we consider cost of power for one unit is Rs 6/- (Approx) then for 206 units total cost saving will Rs 1236 /- approx. for one ladle cycle (Heat).

There are approx 18 ladle cycles per day so,
Daily saving = 18*1236
= Rs 22248/-

So monthly saving = 30*22248
= Rs 6, 67,440/-

5. Advantages & Limitations

5.1 Advantages
1. Very high strength & reduces thermal shocks
2. Reduces chances of formation of skull
3. Increased productivity due to reduced superheat requirements & there by less time in the furnace.
4. Reduces power consumption as well as alloy consumption
5. Maintain molten metal temperature in ladle
6. Furnace patching life increases as tapping temperature decreases.
7. Increase safety of ladle operation by reducing outer shell temperature.

5.2 Limitations
1. Initial cost for application of tiles is more
2. There is less porosity for removing gases
3. Internal cracks in ladle shell may arise as less gases passed from ladle shell
4. If temperature of molten metal in ladle is more then it becomes difficult to reduce increased temperature.
5. It is difficult to repatch insulated ladle early than that of traditional ladle because breaking of insulated ladles lining takes time as lining not cools early.

6. Future Scope
1. We can try insulating tile (Boards) having different thickness, size, density & thermal conductivity & can analyze outer shell temperature, power consumption.
2. We can check outer shell temperature by varying ceramic tiles thickness by keeping same ladle volume
3. We can try other type of insulation such as Magnesia boards, Glass wool type insulation instead of ceramic boards & can study its effect on outer shell temperature, power consumption & Tapping temperature
4. We can study effects on grade of billet, TMT Bars & cooling rate of billet by using ceramic boards.
5. By measuring inside temperature of refractory by infrared camera new covering (Insulating) method can be established.

7. Conclusions
Incorporating an insulating layer between the steel inner shell & ladle lining has reduced heat loss through the ladle lining. Reduction in heat loss has possibility of permanent reduction in tapping temperature with consequent increase of the life not only of furnace lining but also ladle.

1) After incorporating insulating boards we reduced average furnace tapping temperature by 17.45°C means average improvement is about 1.072%. The use of insulating linings allows company to adopt a lower tapping & holding temperature practice and to reduce the variation in metal pouring temperatures as ladle lining remains hot for long time. This results in improved controlled chemistry, reduction in furnace refractory consumption, fewer slag inclusions and temperature related casting defects.
2) Reduce in ladle molten metal temperature on CCM by 13.83°C.
3) Reduce in CCM lifting temperature by 12.0°C.
4) With the help of these boards we have been able to reduce the shell temperature by 102.5°C. The average improvement in ladle outer shell temperature is about 29.13%.This results in better heat storage in ladles and tundishes. On account of better heat retention in ladle and tundishes in the number of cases of liquid metal returning from casters due to low temperature have significantly come down. The maximum temperature of ladle outer shell for the new type of ladle drops to 98°C than traditional ladle & reduces outer shell temp to between 300 – 325°C
5) By the application of insulation boards we achieved our main objective of reduction of power consumption. We could reduce power consumption by 206 KWH which is about 1.39 % of total power consumption.
6) Average payback period works out to be approx 14 days.
7) By using insulation material in ladle to minimize the heat transfer through walls, more heat content will be in molten metal so skull formation also reduced in ladle.
8) The heating time of the new type of ladle was shorter under the same condition, which saves time and energy.
9) Minimize degradation of ladle shell due to hot spots and high shell temperatures.

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