REFRACTORIES FOR STEEL FOUNDRY
1.1. Ingot casting via bottom pouring

Although the percentage of steel produced in the world via ingot casting has decreased to 4.1% in 2012 (World Steel Association Statistical Yearbook 2013), some low-alloy steel grades and steel for special applications can only be produced by this process. Steel casting into the ingots allows even for the production of oversized components weighing up to several hundred tons.

Top pouring is easy to use, but generates many defects both on the surface and internally, which is not suitable for high quality steels. Bottom pouring is better, especially for intensive deoxidation, high superheat, low turbulence, and casting in a nonoxidizing atmosphere. It is also less damaging to ingot molds but requires additional refractory equipment to direct the steel into the molds.

The presence of such additional holloware determines several necessities, which can only be satisfied with an appropriate choice of lining geometries and materials. The refractory must in fact be able to withstand severe thermomechanical stress conditions: the components are exposed to thermal shocks in the beginning of teeming phase, and for the whole process are eroded by the liquid steel flux.

Some steel grades are quite corrosive (such as high-manganese steel or semikilled grades with high soluble oxygen contents) and this can lead, in association with the above described stresses, to a component failure, which in the worst cases can imply a significant economical damage caused by associated events, and not leastly a notable risk for the surrounding workers.
1.2. Problems related to inclusions

Nonmetallic inclusions are a significant problem in cast steels because they may lead to problems in castings that require expensive casting repairs or rejection. The mechanical properties of steel are controlled to a large degree by the volume fraction, size, distribution, composition, and morphology of inclusions and precipitates, which act as stress raisers.

Fracture toughness decreases when inclusions are present, especially in higher-strength lower-ductility alloys. The pronounced property degradation caused by inclusions is observed in tests that reflect slow, rapid, or cyclic strain rates, such as creep, impact, and fatigue testing. The source of most fatigue problems in steel are hard and brittle oxide inclusions.

Large exogenous inclusions also cause inferior surface appearance, poor polishability, reduced resistance to corrosion, and, in severe cases, slag lines and laminations. Inclusions also lower resistance to hydrogen-induced cracks. In machining, they produce chatter, causing pits and gouges on the surface of machined sections, frequent breakage, and excessive tool wear.

Since almost 60% of all exogenous inclusions in killed steels are reported to arise from “attacking” of refractories (P.W. Wright: Met. Forum, 1979, vol. 2 (2), pp. 82-86), the application of high quality materials and the individuation of specific design solutions aiming to the limitation or even the elimination of such negative effects can turn out in a significant improvement of the steel production, with evident positive consequences from the economical point of view.

1.3. Traditional refractory linings

Traditional linings for ingot casting via bottom pouring generally include refractory pipes and channels composed by about ten pieces in sequence; such lining implies the necessity of a complicated and prolonged installation. Moreover, the pressed and fired material of which the pieces are made tends to exhibit an high consumption rate, and to release fragments in the steel flow, which will become inclusions. The high number of joints, real weak points of the structure, also contribute to this phenomenon, because they are less erosion resistant and will turn out to be the first point of attack by the steel flux.
1.4. Innovations by Pallotta S.p.A.: COMIN® refractory products

The ever-increasing demands for high quality have made the steelmaker increasingly aware of the necessity for high performance refractory products to meet stringent “cleanliness” requirements.

Pallotta S.p.A. has a significant experience in this field, and in order to satisfy steelmakers’ needs has developed the COMIN® refractory product line for bottom pouring, applying technologies for the production of prefabricated column pipes and channels even 1.5 meters long or more. The length is equivalent to about 5-6 traditional units, and these refractory items are ready to use, since preheating is not necessary. The COMIN® solutions are protected by patents in several European Countries, and significantly contribute to raise the qualitative standard of the steel. In fact we are the only ones able to propose pipes and channels in castable concrete, which can be personalized according to customer’s needs regarding geometry, including also curves or small scale details.

The abrasion resistance of the material in significantly higher compared to traditional shaped linings, and this implies a drastic reduction of the number and dimension of exogenous inclusions, also thanks to the low number of joints.

A demonstration of these advantages is given by Figure in page 2., where it is possible to appreciate the high performance level of COMIN® products: the steel residuals (“roots”) extracted from the COMIN® channel after stripping have a considerably lower diameter compared to the one extracted from a conventional hollow brick. This clearly indicates a lower wearing, obtained thanks to the excellent abrasion resistance of the applied material.

Moreover, due to the lowering of joint number, the lining placement is considerably easier and faster, thus contributing to a more efficient management of the plant and reducing in the meanwhile the possibility of misalignments.

- HIGH MECHANICAL RESISTANCE
- HIGH THERMAL SHOCK RESISTANCE
- LOW JOINT NUMBER
- EASY AND FAST INSTALLATION
- BROAD POSSIBILITIES FOR GEOMETRICAL CUSTOMIZATIONS
2. Monolithic ladle linings

The substitution of bricks by monolithics in steel ladles is a well established trend. The main drivers behind this substitution are generally considered to be the reduction of overall specific refractory costs (material, installation and maintenance) per ton of steel cast, the improved lives and the decreased wear rates, thereby enhancing steel cleanliness and improving plant flexibility via better ladle availability. Moreover there is also a reduced environmental impact, because with “endless repair” techniques there is a lower volume of spent refractories for disposal.

The weight of these individual drivers varies significantly according to geographic area, country and even steel plant. It is clear that the high rate of penetration of monolithics into steel ladle applications has occurred through the application of a complete solution rather than an individual product offer. It is only by considering the whole refractory usage chain that the full value potential of the monolithic substitution can be realised.

The relatively high raw material costs of these castables compared to bricks would have prohibited their use if the focus had been purely material cost, but the full potential of a monolithic solution can only be realised if continuous repair techniques are utilised.

Monolithics give the best thermomechanical properties for steel ladle applications: not only they allow the castables to sustain the harsh environment coming from aggressive slags, but they also give the refractory designer the flexibility to select the best solution in function of the location of the castable in the ladle. Every section needs for special refractory solutions: therefore Pallotta S.p.A. offers prefabricated monolithic products for all the working areas of the ladle, among which the bottom is the most critical zone, requiring additional attentions and specific products.

- HIGH RESISTANCE AND LOW CONSUMPTION COMPARED TO BRICK LININGS
- BETTER AVAILABILITY OF THE LADLE FLEET
- LOWERING OF COSTS REGARDING DEMOLITION, TRANSPORT AND DISPOSAL OF REFRACTORY WASTES
3. Ladle stopper

Many modern steel foundries use multi-life monoblock stopper technology. The idea originates in steel plants where similar technology is used for tundish applications in long casting campaigns. All standard nozzle shapes are available with a range of inner bore diameters; products can also be made to specific customer specifications. The selection of the correct material and shapes for the flow control system in a ladle or pouring box has a significant impact on the pouring of the castings.

The stopper/nozzle can leak and occasionally fail, resulting in uncontrollable flow of molten metal from the ladle - this is an obvious safety issue. A worn or blocked nozzle will give inconsistent flow rates and mould fill times. Incorrect shape of the stopper and nozzle will result in poor metal flow attributes; the metal will not flow in a consistent stream and may spray out of the nozzle resulting in casting defects from oxidation, air entrapment and erosion of the pouring cup by the metal stream.

The output of the nozzle and its flow rate is usually determined by the inside diameter of the nozzles inner bore and the height of opening of the stopper: for very small casting weights and fast opening campaigns, the pointed nose is suitable, as this provides improved control for small castings. This is mainly applicable to iron auto-pouring furnaces.

The COMIN® products offer excellent thermal shock and oxidation resistance, making them particularly suited as a mono-block stopper for application with molten steel.

The stopper can be used for up to 15 heats, if after the casting process and the cool down of the equipment, the stopper is properly cleaned on a horizontal cleaning station. The slag should be removed carefully with a small hammer, and the tip can be removed and replaced with a new one. A special anti-sticking coating can be applied to the stopper.

The usage of the mono-block stopper technology offers many benefits in the iron and steel foundry casting process. With this multi-use system, the foundry is able to cast many more heats with a single stopper. This reduces gas costs by reducing refractory preheating and generates less waste than monouse stopper rod components.
Other grades are available on the basis of the specific needs, with a broad possibility of customization.