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# Innovative and Safe Copper Launder Design

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**Abstract** – Pyromet has designed copper launders for tapping slag. What makes Pyromet's launder design innovative and safe is that it does not have any cooling water channels underneath the launder runner, whilst achieving effective cooling of the runner. If matte burn-throughs were to occur through the launder runner, the risk of damaging water channels and the risk of explosions are reduced. In addition, since the cooling water channels are not harmed, the launder is easily repairable and reusable. Pyromet makes use of Finite Element Analysis to optimize the launder geometry to ensure that sufficient energy is removed from the centre of the launder. Factors considered during the launder design include the suitability of the geometry to the client's needs, experience from existing installations, and ease of fabrication. Pyromet goes so far as to develop procedures for fabricators to ensure that fabrication issues do not compromise the functionality of the launder. When launder orders are received by Pyromet, the entire fabrication process and the functioning of the launders during operations are monitored to ensure that the launder designs are continuously improving with every installation.

## INTRODUCTION

The slag launders used in industry are either refractory-lined launders or water-cooled launders without refractory lining. The disadvantage of refractory-lined launders is that slag attacks refractories, and therefore the launder requires frequent relining. The advantage over water-cooled launders is the absence of cooling water channels. This reduces the risk of explosions caused by matte burn-throughs that occur due to entrained matte pockets in the slag. Water-cooled launders, on the other hand, have the advantage of not requiring refractory lining, but have the disadvantage of having water channels, particularly under the runner, which could result in explosions when matte burn-throughs occur. In addition, the launders have to be replaced because the launders cannot be repaired once the cooling water channels are damaged. In 2002, Pyromet developed a launder that combines the advantages of both the refractory-lined launder and the water-cooled launder.

## LAUNDER DESIGN

Pyromet's patented copper launders are designed for tapping slag. The driving principle behind the use of copper launders is their high rate of energy removal. This is attributed to the high thermal conductivity of copper. At 300 $W/m^2K$ it is much higher than that of steel, which is around 40 $W/m^2K$. By removing the energy from the slag at a high rate, the copper's surface temperature can be kept below temperatures that result in launder damage. This feature of copper launders is the reason for the redundancy of the refractory lining. However, from time to time, entrained pockets of matte are present in the slag. It is these matte pockets that are the cause of the burn-throughs experienced on copper launders because the rate of energy transfer from matte to copper is much greater than the rate at which energy can be removed from the copper. Entrained matte or accidental matte tapping is rare, which is why copper launders are still used widely even with the possibility of burn-throughs. Tapholes with copper launders that normally have entrained matte pockets when tapping have developed standard practices of placing a thin refractory layer on the copper for the initial tap, thereby giving the copper launder some initial protection.

What makes the Pyromet launder design innovative and safe compared to other copper launders is that it does not have any water channels under the runner, while still effectively removing the energy from the runner through the sidewall cooling channels. Therefore, on those occasions when matte burn-throughs occur, there is a reduced chance of explosions. In addition, since the water channels are not damaged, the launder can be repaired and reused.

Pyromet has designed and made launders of various lengths with either drilled water passages or cast-in pipes. The maximum length of the launder is restricted by whether the water passages are drilled, or whether cast-in pipes are used. Launder sections longer than 2 m could result in the drill bit drifting out of the sidewalls. The Pyromet launders that are longer than 2 m are made up of launder sections that are bolted together. This not only allows one to drill the water passages, but also provides the client with the flexibility to change damaged sections rather than replacing an entire launder. Photographs showing examples of a launder less than 2 m (known as a launder spout) and a 7 m long launder are shown in Figure 1.

|  |  |
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| Launder spout | 7m long launder |

**Figure 1:** Pyromet's patented copper launder design

The drilled water passages are the ideal case, because the energy transfer occurs through the parent material. However, there are some clients that require cast-in pipes for their launders for safety reasons, or if the launder is greater than 2 m in length and has to be cast as a single piece. For effective energy removal through the water pipes, it is important that there is a good bond between the copper launder and the pipes. For this reason, in 2000, Pyromet conducted independent research on cast-in pipes. The investigation involved the casting of copper samples with various types of pipe: stainless steel, monel, and copper pipes. The results of these tests found that the best bond was achieved with monel pipes. It is known that there has been a development in cast-in pipe methodology that has improved the bond between copper pipe and the copper launder that Pyromet is currently to investigating.

The design process and some insight into the evolution of some of the basic Pyromet launder features are described below.

## DESIGN PROCESS

The basic principle of the design is to optimize the launder's geometry such that energy is effectively removed from the centre of the launder through the cooling water channels in the sidewalls. A Finite Element Analysis (FEA) model is run for every launder design to optimize the geometry.

For each client, the design process is similar. Initially, a three-dimensional launder model of the proposed design is drawn using a Computer Aided Design (CAD) package. Then, using the slag assay results, the tapping temperature, and tapping rate (acquired from the client), an estimate is made of the specific heat, the conductivity, and the convective heat transfer coefficient for the slag. The values are then applied to the launder model, and a static FEA thermal analysis is done.

Figure 2 shows typical thermal and energy flux results for a typical launder cross section. The geometry of the model is then adjusted, or the number of cooling water runs increased, to ensure that the copper hot face temperature is less than 800°C to prevent erosion of the copper. The bulk temperature of the copper launder must be below 400°C, because at this temperature, and higher, copper generally loses most of its strength.

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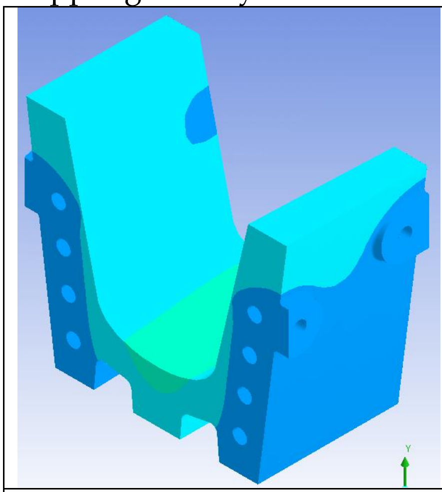
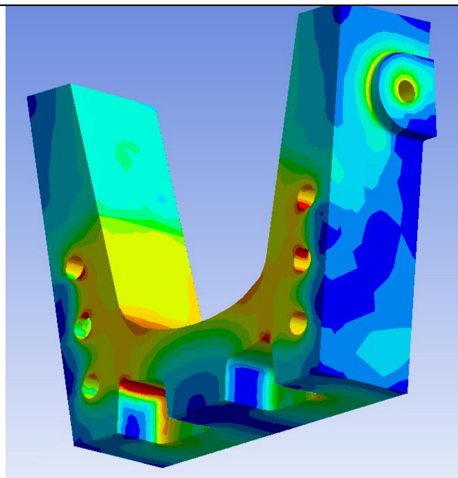
|  |  |
| Thermal results – showing a maximum runner T of ~300°C | Energy flux results |

**Figure 2:** Typical results from FEA model

## DESIGN INFLUENCES

Pyromet has designed launders with various profiles and shapes to suit the needs of the client. The consistent factor in all of the designs is that there are no cooling water channels under the launder runner. Some examples of customised launder designs are shown in Figure 3.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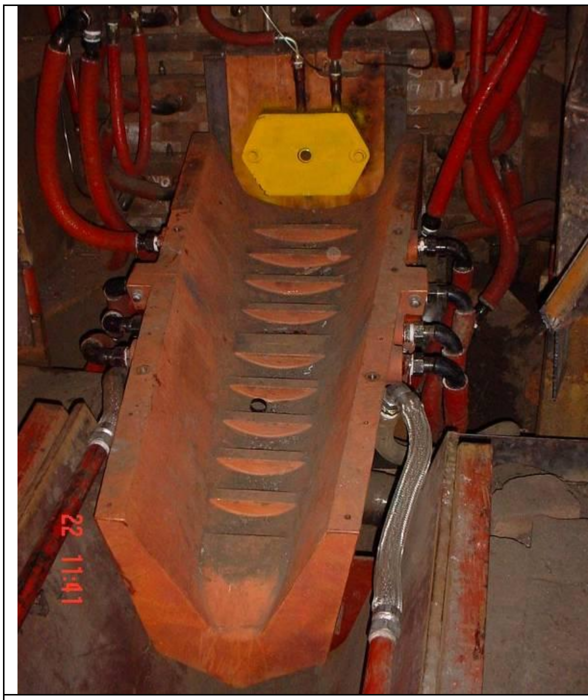
|---|---|
| Refractory inserts | Angled start section |

**Figure 3:** Examples of customised profiles, shapes, and lengths of Pyromet launder designs

For one application, refractory inserts were used, as large quantities of matte were entrained in the slag. As shown in Figure 3, steps were cast into the launder to hold the refractory inserts. For another application, an angled start section was required, as shown in Figure 3. The bottom of the launder is shaped to fit under the taphole and for the launder to lie at an angle.

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| Launder with the rib designed runner | Launder with a smooth runner |

**Figure 4:** Evolution of the launder runner design

From the first design made in 2002, a number of the launder features evolved to improve its functionality. For example, the launder runner initially had ribs to trap slag, and, in so doing, to encourage a slag crust to form as a protective layer inside the launder. After installation, this was found to encourage splashing of the slag, and the ribs were therefore cast over with a flat surface. The comparison is shown in Figure 4.

The shape of the launder tip has also evolved. It changed from a rounded edge to a square edge, as shown in Figure 5. This change was also influenced by experience obtained through an existing installation. The tip with the rounded edge resulted in a slag flow where the slag maintained contact with the tip, damaging the tip beard, as shown in Figure 6. By modifying the design to a square edge tip, the slag separates from the tip and therefore does not cause major wearing of the tip beard.

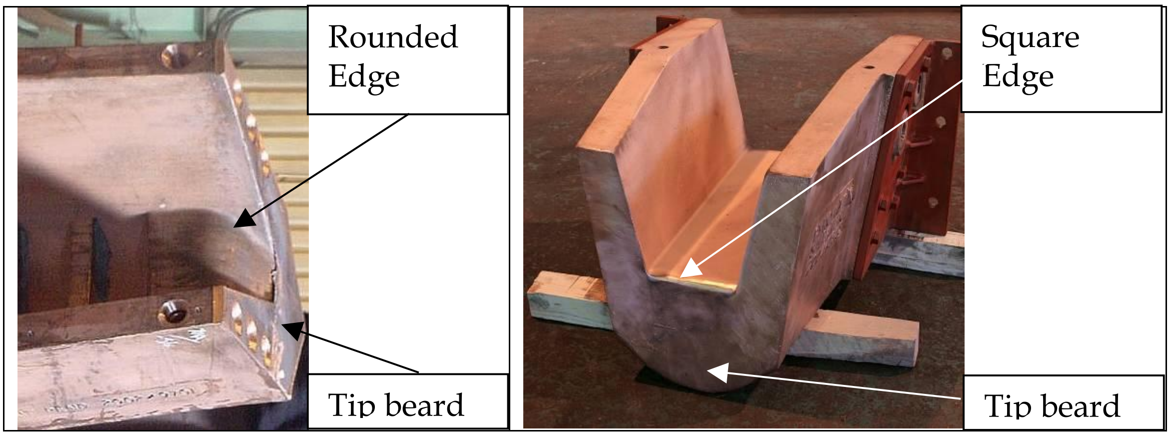



**Figure 5:** Launder tip profiles

**Figure 6:** Repaired launder tip that originally had the rounded launder edge

Experience resulted in the design change shown in Figure 7. These changes were made because the initial design, which consisted of two bolted sections, began to pull away from each other, forming an opening in the middle of the launder. It is believed that the cause of the launders pulling away from each other was a combination of the thermal expansion of the copper and insufficient rigidity down the centre of the launder. The solutions that arose involved an increase in the cooling to reduce the amount of thermal expansion.

Additionally, where possible, narrower launders where designed and a rib running down the centre of the launder was added to increase rigidity. A steel plate was introduced between launder sections to further increase rigidity and to capture slag in the event the launders pull apart. Since the introduction of these measures, none of the launders have experienced the phenomena of pulling away from each other.

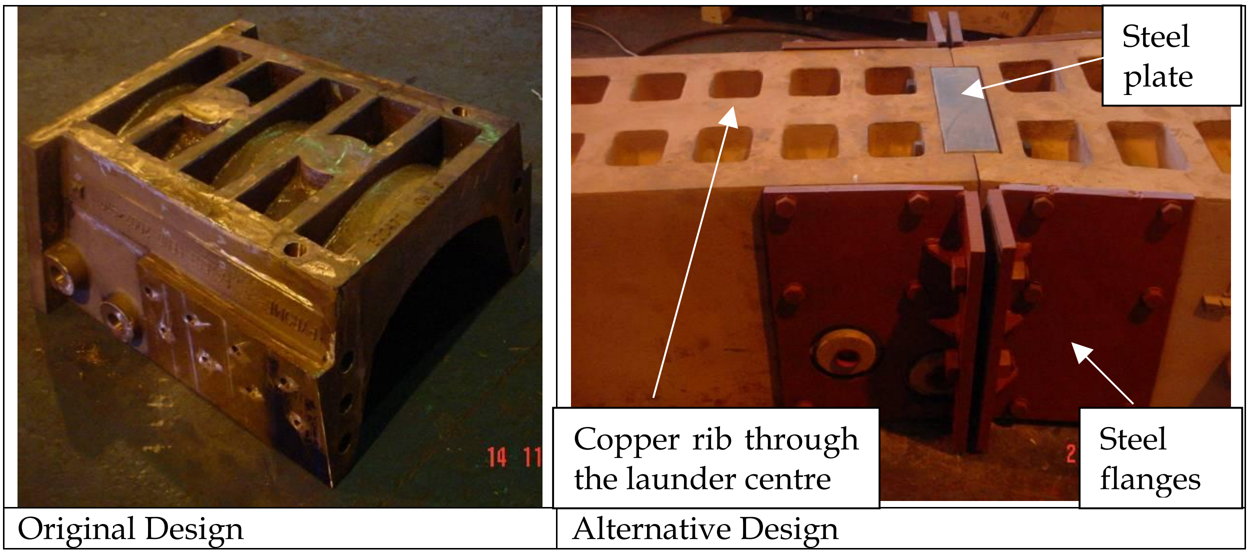



**Figure 7:** Changes to the launder design

## FABRICATION OF THE LAUNDERS

All the launders that Pyromet has supplied are cast launders. Pyromet actively monitors the fabrication process, from pattern making, to casting, to machining, and testing is monitored to ensure that the fabrication of the launder influences the launder functionality positively, when an order is placed on Pyromet. Where required, improvements are made to make fabrication easier, and to ensure that there is no compromise on quality. For example, the pocket patterns were modified slightly to allow for ease of removal of the pattern from the mould. Another example is in the restriction of launders with drilled passages to less than 2 m to ensure minimal drill-bit drifting.

Together with the foundry, Pyromet has developed a plugging technique, as shown below, that has thus far worked effectively on the launders. This was important because the majority of the Pyromet launders fabricated have drilled water passages and one of the known problems in the past with drilled water passages is the plugging of the drilling holes. Some bad experiences in industry with plugged holes include leaking of water from the plugged ends and the plug loosening over time due to corrosion at welds resulting in plugs being dislodged. The plugging method is illustrated in Figure 8. The first method is used for most launder sections, except for the tip. The second method involves threading the hole so that the plug is held in position by threads. This is applied as an added safety mechanism to lock the plug in place and prevent the plug from becoming dislodged, even if the weld corrodes. As shown in Figure 9, the welding of the plugs is done in such a way that the welded surface is smooth and does not provide any pit holes that could encourage localised corrosion. So far there have been no complaints of the plugs ever coming out or leaking during operation.

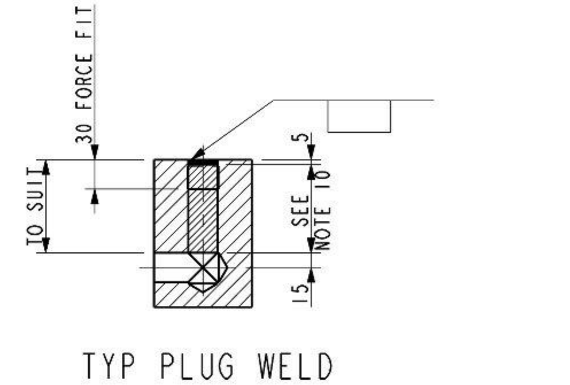
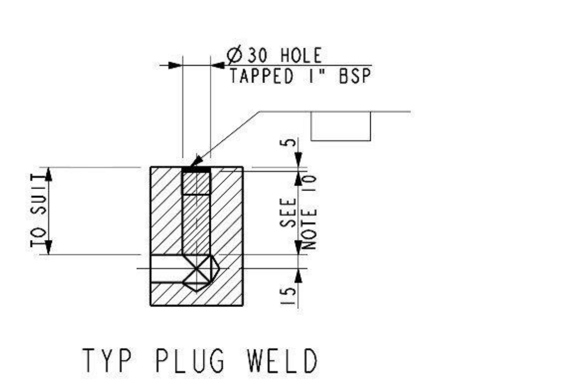
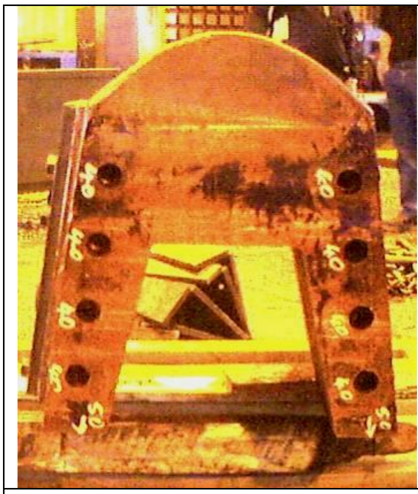
|  |  |
|---|---|
| Method 1 | Method 2 |

**Figure 8:** Plugging technique for drilled water passages

|  |  |
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| Tip after drilling of water passages | Tip after plugging |

**Figure 9:** Pictures of the typical launder tips with plugged water passages

## INSTALLATIONS OF PYROMET'S COPPER LAUNDERS

In 2002, Pyromet installed the first patented copper spouts at Anglo Platinum's Waterval Smelter in Rustenburg, under the slag tapholes on the slag-cleaning furnace. The slag tapped is a fayalytic slag, at temperatures up to 1600°C. During operation, matte was tapped out of the slag taphole, resulting in the burn-through shown in Figure 10. No explosions were reported and there were no damaged water passages, so the launder was therefore repaired and reused.

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|  |  |
| Burn through in the launder | Launder after burn-through was repaired |

**Figure 10:** Burn-through example

The originally required launders are still in use after 2.5 years of operation. Subsequently, Anglo Platinum bought an additional eleven launders to be placed on the six-in-line furnaces and for spares.

Some of the unusual designs Pyromet has done include the Y-piece (shown in Figure 11) for BCL, a nickel producer in Botswana. This piece was one of several launder sections supplied to BCL. The original Y-piece consisted of two components bolted together. Pyromet designed a single cast Y-piece with drilled water passages and with an inner profile that matched with their existing launders. The Y-piece has not been installed as yet, but one straight launder, of approximately 7 m in length was installed between the electric furnaces and along the launder between the flash furnace and the electric furnace, transferring slag that reaches 1300°C. The launder is still in operation and also proved to be safe in terms of not having explosions when burn-throughs occur.

**Figure 11:** BCL launder - trial assembly

STL, a cobalt producer in the Democratic Republic of Congo installed a full launder in 2004. The launder in operation is shown in Figure 12. Following the success of this installation, they ordered an additional full launder for the taphole adjacent to the one in the figure.

**Figure 12:** STL - Pyromet launders in use

## CONCLUSIONS

Since 2002, Pyromet has been designing launders with sidewall cooling that removes energy effectively from the centre of the launder so that there is no need to put cooling-water passages under the runner where they would be positioned for potential damage and where they could be the cause of explosions. Using FEA, the designs are optimized to ensure that the energy removal is sufficient to maintain copper temperatures below 800°C to prevent copper erosion and below 400°C on sections where structural integrity is important. The fabrication process is also key to ensuring the design functions according to specification, and is therefore monitored and influenced by Pyromet. This patented design has been proven to function without cooling water channels under the runner and has, to date, not resulted in any explosions during matte or metal burn-throughs. They have also been proven to be easily repairable and therefore reusable. The Pyromet launder design has evolved over the years and it is certain that the design will continue to be improved with every installation.

## ACKNOWLEDGEMENTS

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