



Figure 1: Pouring ladle in action. (Source: <https://www.eastcarb.com/ladle-furnace/>)

HOW TO PROTECT THE EXPOSED SURFACES OF A LADLE AND A CHUTE IN FOUNDRIES

A nickel smelter case study

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FOREWORD

In metalmaking, a ladle (Figure 1) is a bucket-shaped vessel used to transport and pour molten metal. Ladles are typically, though not exclusively, used in foundries for casting, transferring, or treating molten metal and can have a capacity of up to 300 tonnes.

They are generally lined with refractory material and serve as intermediate containers that facilitate the transfer of molten metal from the primary furnace to secondary processing units such as casting machines or continuous casting moulds.

Within the metal production chain, the ladle plays a vital role by holding molten metal in a controlled environment, enabling precise temperature regulation, chemical adjustments, and inclusion control. Positioned between the primary melting stage and casting, it acts as a crucial link, ensuring the quality and consistency of the molten metal prior to solidification.

The complementary tool to the ladle is the chute (Figure 2), which ensures proper and smooth pouring of molten metal into or out of the ladle.

It is therefore essential for uninterrupted and safe production to keep both the ladle and chute in optimal condition. Protecting their exposed surfaces from erosion is a clear priority for operations and/or maintenance management.



Figure 2: Chute in operation. (Source: <https://www.manager-magazin.de/unternehmen/metall-raubzug-aurubis-beziffert-schaden-nach-inventur-auf-185-millionen-euro-aktie-steigt-a-21bbbc16-959c-489f-8784-3fd2069ad778>)

INTRODUCTION

Conventionally, the interior surface of the ladle is lined with refractory material to insulate the molten metal from the steel wall, reduce heat loss and at the same time prevent contamination of the molten metal by the ladle steel. Nevertheless, there are still exposed surfaces on the ladle that may come into contact with the molten material and suffer severe damage. These areas are usually located along the circular edge (including the pouring lips) and on the outer surfaces. The latter may come into contact with molten metal if the ladle is misaligned and metal flows or

splashes onto it, while the pouring lips are subject to regular pouring and therefore constant wear. This is even more true for chutes, which are rarely lined with refractory material. The molten metal causes erosion and thermal shock to the exposed surfaces of the ladle and chute, resulting in significant metal loss. Consequently, maintenance personnel are examining ways to obtain a cost-effective, wear-resistant overlay that ensures a longer service life. This paper addresses this challenge using the detailed case study presented below.

DISCUSSION

A $\varnothing 2500$ mm ladle with around 2000 mm depth and 100-180 mm wall thickness (Figure 3) and a 4000 mm long cast chute (Figure 4) are the subjects of this case study. Both the ladle and the chute are made of cast steel and are used for molten nickel transportation.

The restoration of the ladle began with the removal of the refractory lining. This state can be seen in Figure 3, as the welding work begins.

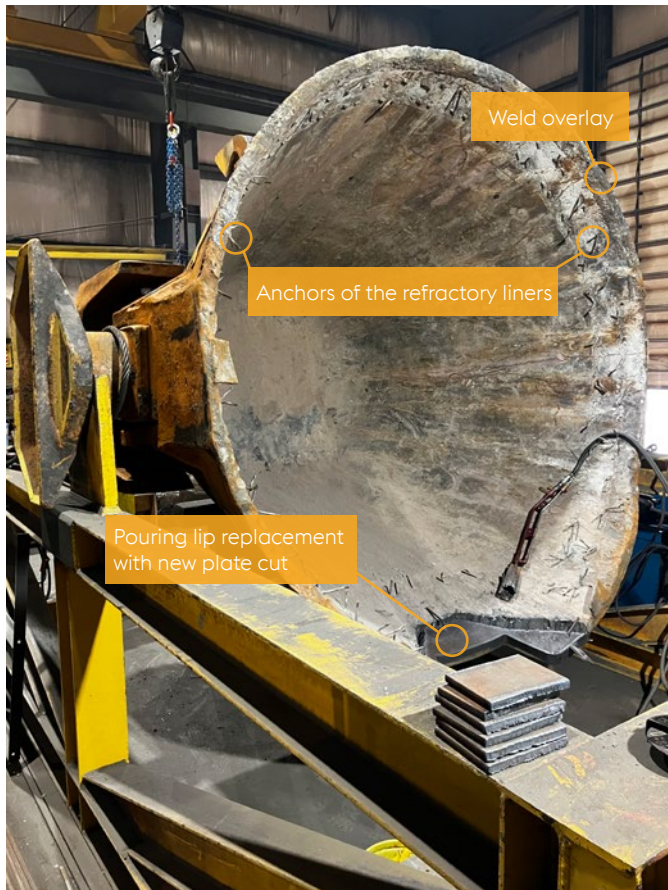


Figure 3: Repair work on a casting ladle in a workshop with refractory materials removed. Note the anchors of the refractory lining and the surface where hardfaced protection against the molten metal has been applied.



Figure 4: Molten nickel chute, side view.

The welding phase includes both joining and hardfacing. As can be seen at the bottom edge of Figure 3, the pouring lip part was severely worn, making replacement necessary. This replacement process can be seen in the figure. The removed lip is being replaced with a new steel plate that has been cut to size and prepared for joining (Figure 5).



Figure 5: Pouring lip replacement in progress.

Finally, the verge hardfacing happens. This area of the ladle is regularly exposed to either random or operational splashes or flows of molten metal during the filling and/or the pouring process, so the correct alloy selection is our case study here.

The stress is more evident in this case of a chute whose inner surface was not lined with refractory material, as the molten metal affected the entire surface more actively, which can be seen in on Figure 6.



Figure 6: The interior view of a worn chute from a nickel smelter.

In the past, a product with a moderately high carbon-chromium content (Table 1) was listed as the recommended solution for the foundry in question. As this suggestion is a legacy from the past, we do not wish to criticise it—this may have been the best solution at the time it was originally implemented— rather we strive to work out a recommendation for a more reliable and durable welding metal for the future.

Chemical component	Average values
C%	2.2
Si%	1.0
Mn%	1.2
Cr%	11.0
Al%	0.6
Mo%	0.5

Table 1: The average chemical composition of the overlay traditionally applied to the edges of the ladle and the inner sides of the chutes.

Why is it our goal to find a more reliable solution for hardfacing? The reason is that the overlay mentioned above tends to spall prematurely. The spalling phenomenon is clearly visible on the bottom and inside of the chute. Figure 7 provides a better understanding and a basis for comparison. The black ellipse marks the normal destruction of the overlay caused by erosion from molten nickel flow in the chute. This wear is predictable, so maintenance intervals can be adjusted accordingly. However, the orange ellipse indicates spalling that represents premature failure. This is unpredictable and must therefore be eliminated in terms of maintenance.

The next chapter shows how Böhler Welding and UTP can support foundries and smelters in meeting the challenge described above.



Figure 7: Close-up of a nickel chute. Note the surface defects caused by erosion (small ellipse) and spalling (big ellipse).

SOLUTION

Taking into account the stress factors, cobalt alloys would be a universal, and definitely, very durable solution. However, they would also be exaggerated at the same time due to their cost. Smelters and foundries tend to be more conservative and practical in their approaches and therefore avoid using exotic alloys in their maintenance work. Apart from repair habits and traditions, cobalt alloys are ideal for high temperatures in conjunction with metal-to-metal friction (galling) and acidic media. However, the latter two factors are not present in the surface stress of casting ladles and chutes, so the use of cobalt alloys is not justified.

These considerations raised the question: Which alloy would be the best overlay for this specific application, posing no risk of spalling or other premature surface defects?

Theoretically, it can be said that the addition of chromium and carbon helps to increase heat resistance, as in creep resistant steels, for example, but at a certain point this effect reverses and begins to reduce heat-shock resistance. This reaction is obviously the result of the increase in hard-



ness that occurs when there is a gradual increase in carbon and chromium content. Therefore, based solely on theoretical considerations, the conclusion was obvious: low-alloy filler metal can outperform the higher-alloy ones!

Based on further considerations, UTP ROBOTIC 603 and UTP ROBOTIC 600 (Table 2) were selected for a field test against the conventional alloy (Table 1).

During the welding process, the subcontractor highlighted the outstanding performance of the UTP ROBOTIC wires. The wires were characterised by significantly reduced spatter, excellent weldability, and a notably improved weld appearance.

The field evaluation was carried out on the circular edge of a ladle in a nickel smelter.

The original service life of the CCO was 2-3 months.

UTP ROBOTIC 603 achieved a service life of four months, which is twice as long as the previous solution. Spalling was significantly reduced, but not completely eliminated.

Chemical component	UTP ROBOTIC 603	UTP ROBOTIC 600
C%	0.5	0.45
Si%	1.0	3.0
Mn%	1.1	0.4
Cr%	5.5	9.0
Mo%	1.3	-
Other	V: 0.3 / W: 1.3	-

Table 2: The chemical composition of UTP ROBOTIC 603 and 600

The most recently tested wire, UTP ROBOTIC 600's weld deposit, achieved a service life of six months! In addition to tripling the service life of the original welding wire, it delivered the best performance with almost completely spalling-free operation (Figure 8). However, minor spalling may still occur after the normal service life has expired. This result was a major improvement, but not the final result for UTP.

Product information UTP ROBOTIC 600

UTP ROBOTIC 600 is a seamless, chromium-alloyed, metal-cored wire for wear-resistant hardfacing applications on components that are exposed to a combination of pressure, impact and abrasion wear. Very good weldability compared to solid wires, good resistance to abrasion, minimised slag formation with easy slag removal. Thanks to its constant wire feed and excellent weldability, this wire is particularly suitable for automated welding.

Hardness (as-welded)	Max. Deposit thickness	Alloy type	Cutting / machining
57-62 HRC	Max. 3 layers	C-Si-Cr	No flame cut, grinding only
Other			
Diameters	Shielding gas	Polarity	Stick-out
1.2 mm 1.4 mm 1.6 mm	M21	DC+	20-25 mm

A subsequent improvement to the repair process further extended the service life of the UTP solution. By applying an AISI 309 buffer layer (FOXcore 309L-T1) prior to the UTP ROBOTIC 600 hardfacing, the life cycle increased dramatically to approximately 12 months. This simple modification improved bonding, reduced spalling, and provided a more stable transition between the base material and the hardfacing overlay.

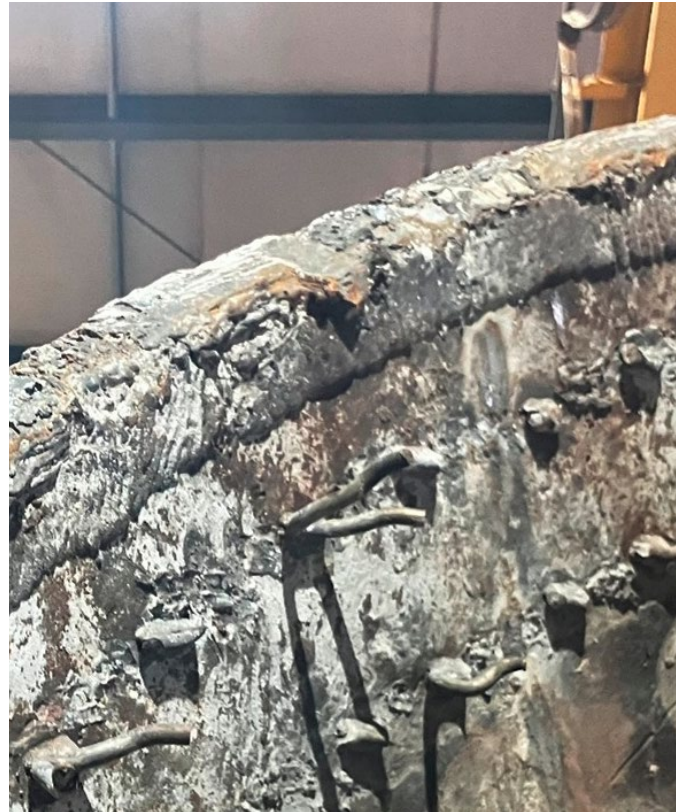


Figure 8: The circular edge of the field-tested nickel ladle. Note the worn but still recognisable hardfaced layer on the edge and the marking above the refractory anchors.

CONCLUSION

The customer was thoroughly satisfied and recognised that the solution provided by Böhler Welding and UTP was significantly superior to their previous process in terms of service life. The superior performance of the UTP ROBOTIC 600 achieved led to a change in traditions and habits and heralded a new era in nickel smelting.



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Tamás conducted his studies at the Budapest University of Technology and Economics, at the Faculty of Mechanical Engineering, and Welding Science, which was followed by the International Welding Engineer postgraduate study. In 2014, he acquired his PhD degree from Welding Science.

Working in the industry from 2003, Tamás has more than 20 years of experience in the areas of mechanical engineering, product-, sales- and marketing management as well as welding laboratory management with special focus and expertise in various hardfacing industry segments.



Tom Russel

Tom Russell is the Territory Sales Manager for Ontario at voestalpine Böhler Welding Canada. With over 20 years of experience in the welding and industrial sectors, including roles in chemical sales, gas distribution, and wear protection, Tom specializes in hardfacing, maintenance, and repair solutions for the mining, cement, and forestry industries. His hands-on expertise and customer-focused approach help bridge the gap between field challenges and innovative welding technologies that drive safer, more efficient, and more sustainable operations.

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